OIL, GAS AND PETROCHEMICAL PROCESSING

Petroleum Refiner

OCTOBER
1959

A SPECIAL REPORT
MATERIALS OF CONSTRUCTION
... For Urea Plants 98
... At Low Temperatures 107

PROCESS TRENDS
How Japan Fills Rubber Needs 111

AUTOMATION TODAY
Check on Controller Stability 115

SUCCESSFUL JOBS
How to Manage a Project 149

EASY FORMULA
Giving the Impromptu Speech 225

For a "Quick Look" at this issue, turn the page . . .

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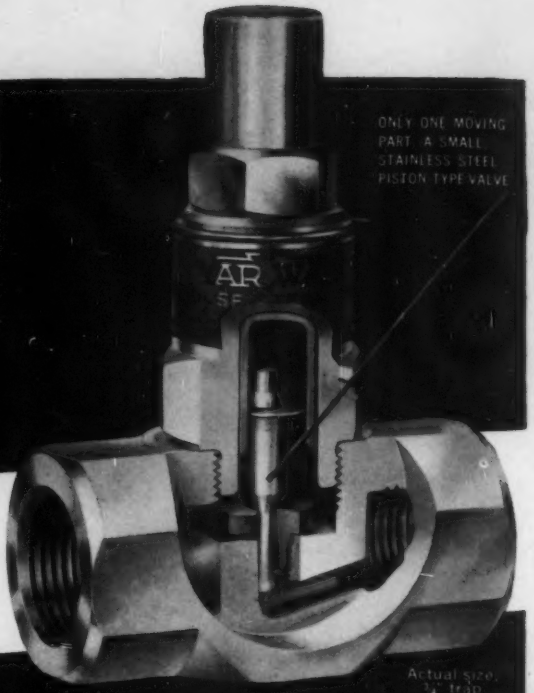

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MATERIALS OF CONSTRUCTION SPECIAL REPORT

Materials of Construction for Urea Plants..... 98
I. Wilenitz

Materials of Construction for Sub-Zero Temperature Service 107
Milo Palmer

OTHER TECHNICAL ARTICLES

Find Toluene Properties by Nomogram.....110
A. M. P. Tans

How Japan Fills Synthetic Rubber Needs.....111
H. Kawasaki, H. D. Noll and A. K. Logwinuk

Automation Today (Part 15).....115
Theodore J. Williams and Verlin A. Lauher

Optimum Boiler Blowdown Saves Money.....119
N. H. Prater and D. W. Antonacci

Pressure Vessel Foundation Design.....121
I. A. A. Cummins

Use These Charts for Fast Pipe Sizing.....127
G. C. Lammers and W. G. Otis

Piping Stress Analysis Simplified.....133
J. S. Moloney

Figure Distillation This New Way (Part 3).....139
W. N. Lyster, S. L. Sullivan, Jr., D. S. Billingsley and C. D. Holland

New Equation Correlates MVP and RVP.....147
A. Y. Mottlau

How to Manage an Engineering Project.....149
John F. McGarry

European vs. U.S. Steel Specifications.....159
M. S. Northup and A. B. Ciuffreda

Applied Hydrocarbon Thermodynamics (Part 14).....163
Wayne C. Edmister

Bottom Loading Tank Trucks Successful.....171
W. L. Hunter

Operator's Handbook for Gasoline Plants (Part 4).....173

Taking Stock.....178

As Management Sees It . . .

Three Hard Speeches to Make.....225
George McWilliams

Standard Procedures Aren't Enough!.....229
James B. Howard

The Fine Art of Human Relations.....235
Stephen G. Henry

DEPARTMENTS

LOOK BOX, Featuring . . .
Today's Story of Cain and Abel..... 13

CONSTRUCTION BOXSCORE, Featuring . . .
Bigger Refineries Are On the Way.....200

Quick Look at Industry.. 9
Mail Box..... 88
Valuable Reading Ahead 182
How To Do It..... 184
Who's Building.....190
Construction Boxscore... 200
New Books.....240
What's Happening.....246
Meetings Calendar.....262
Men in Industry.....264
Suppliers Notes.....286
Classified Advertising....313
New Equipment and Literature 315
Advertisers Index.....344

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Petroleum Refiner

OIL, GAS AND PETROCHEMICAL PROCESSING

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A Quick Look at This Issue

These handy digests permit checking ☑ the articles you want to read first.

MATERIALS OF CONSTRUCTION SPECIAL REPORT

☐ **Materials of Construction for Urea Plants . . .** With accent on the Pechiney-Grace process, this article covers the performance of materials commonly used in urea synthesis plants. It discusses three main material classes: ferrous metals and alloys, non-ferrous metals and alloys and non-metals. For your guide to the type of materials to use in urea service, turn to **Page 98.**

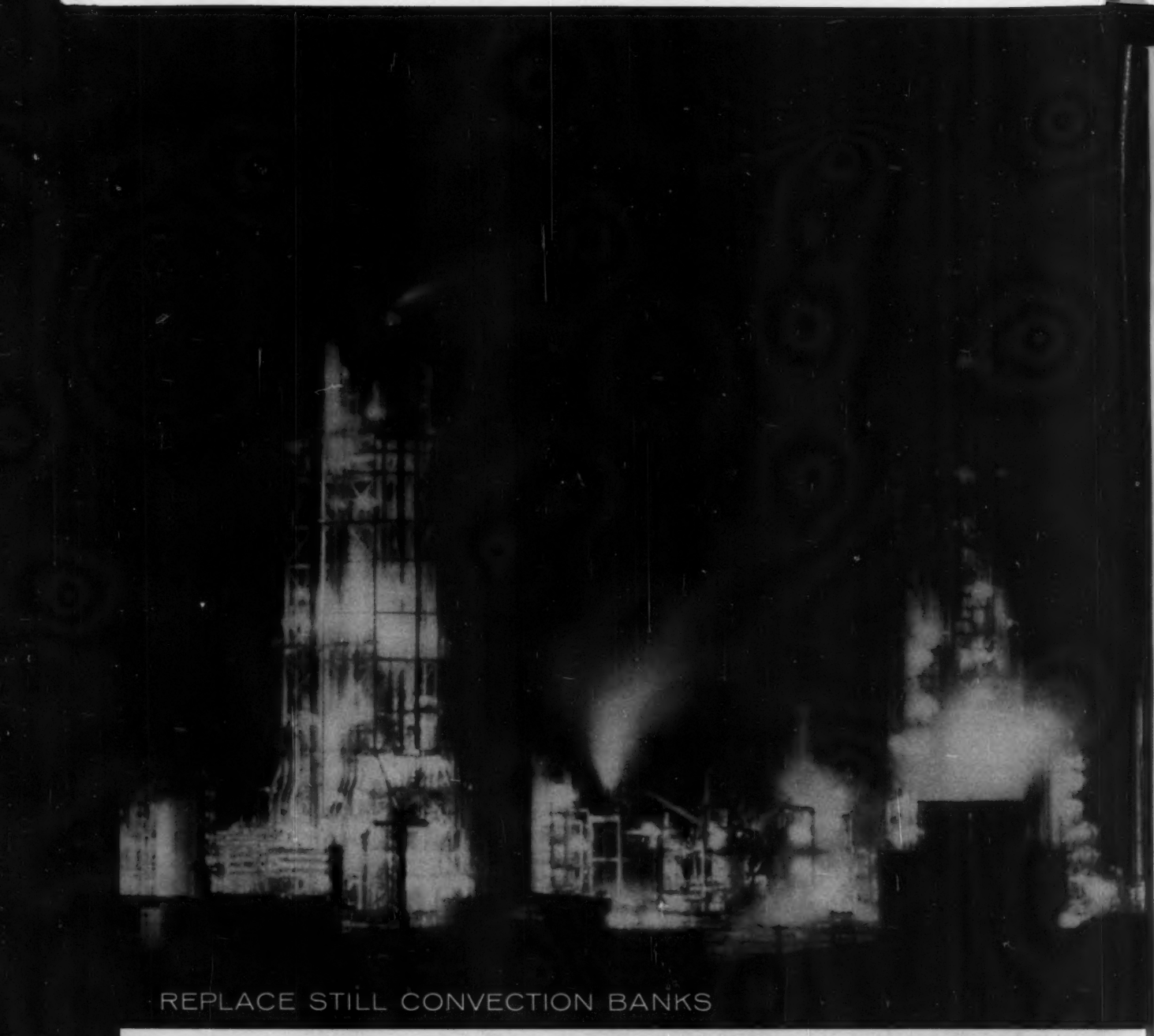
☐ **Material of Construction For Sub-Zero Temperature Service . . .** You should consider material behavior, relative costs, availability and mechanical design when selecting materials for low temperature service. Fortunately, here is an article that discusses them for you, along with piping and equipment design. You'll find the materials to use on your next sub-zero project by turning to **Page 107.**

☐ **Find Toluene Properties by Nomogram . . .** Here's a circular chart which presents all the physical properties of toluene. Clip this for your notebook, turn to **Page 110.**

☐ **How Japan Fills Synthetic Rubber Needs . . .** Careful gathering of petroleum raw materials and selective processing will enable Japan to meet its synthetic rubber needs. For a study of process evaluation, turn to **Page 111.**

☐ **Automation Today (Part 15) . . .** This is the first in the renewal of a series to acquaint you with some of the basic concepts of automatic control. The series starts again by introducing one of the two methods commonly used to determine the proper controller to employ on a process and how to check process-controller stability. Read this discussion of the Nyquist diagrams, starting on **Page 115.**

Please Turn Page ➔



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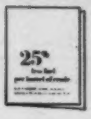

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A Quick Look at This Issue . . .

☐ **Optimum Boiler Blowdown Saves Money . . .** by reducing fuel and make-up water treatment costs. For further benefits from optimizing boiler continuous blowdown, be sure you turn to **Page 119.**

☐ **Pressure Vessel Foundation Design . . .** If the wind loading resultant falls outside the middle third of the foundation cross section, the middle third rule requires a safety factor of 3 to insure against overturning. When you read this article, though, you'll find that a factor of 1.5 is quite in order which will, of course, give you a more economical design. To see how this method can be applied to your design problems, turn to **Page 121.**

☐ **Use These Charts for Fast Pipe Size . . .** You'll find that the charts in this article save you a great deal of time by simplifying and shortening the laborious task of sizing a number of process pipe lines. Based on standard flow equations, they're something you'll want by your side every working day. See for yourself—turn to **Page 127.**

☐ **Piping Stress Analysis Simplified . . .** By using the moment distribution method, you can analyse piping stresses fairly rapidly and obtain very accurate results by using reasonably simple calculations. You can apply this method to very simple as well as to more complex pipe lines. For complete details on how to use the system including two very practical examples, turn now to **Page 133.**

☐ **Figure Distillation This New Way (Part 3) . . .** You can handle complex distillation columns having any number of feed plates and side-streams with this new computational method. If you are considering using a computer to calculate your next multicomponent distillation column, review the new method in this article in order to get rapid convergence. It is a powerful tool for exploring distillation variables, so be sure to start reading on **Page 139.**

☐ **New Equation Correlates MVP and RVP . . .** with high accuracy. Statistical data from extensive testing give an equation for converting micro vapor pressures (MVP) to familiar Reid vapor pressure numerical results. For complete details, turn to **Page 147.**

☐ **How to Manage an Engineering Project . . .** Success or failure of a process construction job depends largely on good project management. The responsibility of this management lies with the project engineer—and this article details that responsibility. To see how you should manage a project, turn to **Page 149.**

☐ **European vs. U.S. Steel Specifications . . .** If you plan to buy European steel for refinery construction, this article helps tremendously in categorizing the various European standards with ASTM specifications. It also tells you the type of steels available from each country, the standards organization of the country plus a table that compares their standard specification numbers with ASTM specifications. For these complete details on comparing European steel with U.S. steel, turn to **Page 159.**

☐ **Applied Hydrocarbon Thermodynamics (Part 14) . . . Integral Technique for Vapor-Liquid In Petroleum Distillation Calculations . . .** If you have always felt that the integral method was too complex for you to follow, just spend a little time with this article by Edmister. In addition to a discussion of the basic principles involved he gives you four typical problems with easy step-by-step solutions. You'll find all this on **Page 163.**

☐ **Bottom-Loading Tank Trucks Successful . . .** The system has proven to be safe, fast, sound and practical for loading tank trucks. Bottom-loading will probably become the standard industry-wide system for road transport trucks in the future. For a quick review of how it's done, turn now to **Page 171.**

☐ **Three Hard Speeches to Make . . .** Called upon for an impromptu speech would you "er" and "ah" and thoroughly embarrass yourself and your audience? Not if you know and use the formula presented in this article. There are also tips and suggestions on how to introduce other speakers and how to say "thank you" following their talks. You'll want to clip this article and save it for reference. Turn to **Page 225.**

☐ **The Fine Art of Human Relations . . .** You can buy a man's time. You can buy a man's physical presence in a given place. But you cannot buy initiative —you cannot buy loyalty—you cannot buy enthusiasm. These have to be earned. You'll remember this article for a long time when it comes to learning how to handle people. Turn now to **Page 229.**

☐ **Standard Procedures Aren't Enough! . . .** During startups, shutdowns and emergencies, standard procedures are necessary. But in learning daily safe and economical operations, planned procedures and operating manuals aren't the whole answer. You'll get the complete story by turning to **Page 235.**

☐ **Operator's Handbook for Gasoline Plants . . .** This part on engines and compressors is one of a series that simplifies operations and equipment for the new and experienced operator in a natural gasoline plant. **Page 173.**

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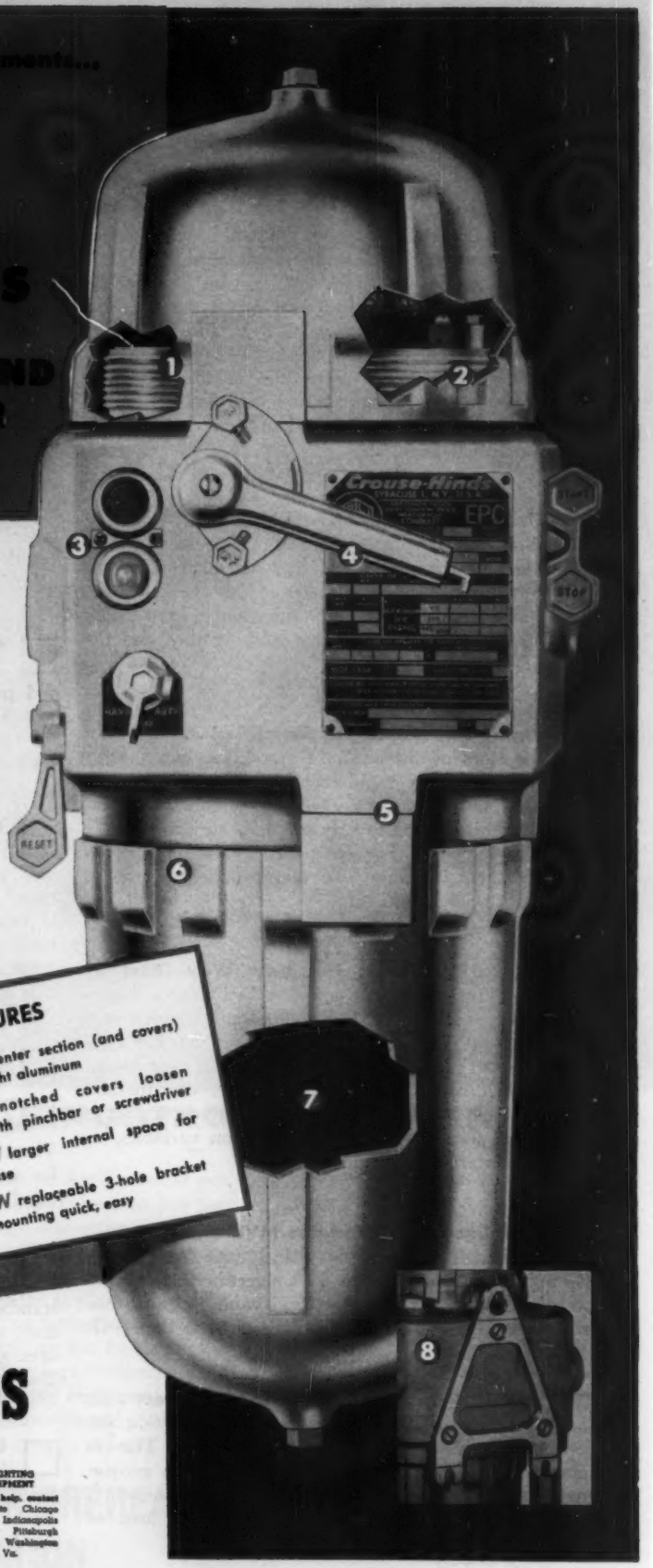

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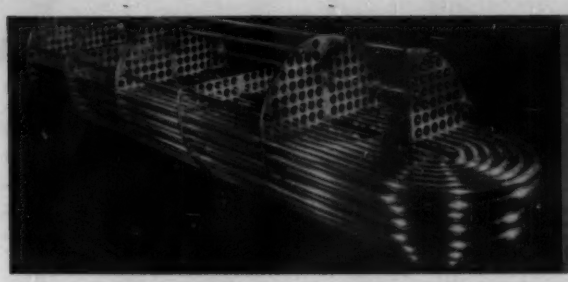
DURING OCTOBER more than 4,000 publisher, advertising agency, and advertiser members are observing the 45th anniversary of the Audit Bureau of Circulations, the non-profit and highly respected guardian of ethical standards governing audited circulation reports. Only publications with paid subscribers can belong. Gulf Publishing Company's three publications (with a combined circulation of more than 54,000 which is nearly 9,000 more than any other weekly or monthly editorial effort that serves the same branches of the oil industry) all belong to ABC. GPC's recognized success stems from the concept that editorial quality builds paid circulation; that paid subscriptions reflect a reader's judgment of the editorial quality of a publication; and that advertisers get the most for their money in a specialized, audited, paid circulation periodical. ABC, through its regular audits of paid circulation publications, is involved in all three of these concepts. Its role is important, not only to PETROLEUM REFINER but also to you the reader because a consistent high editorial standard is called for. So when you add ABC and GPC the result is a publication that gives both reader and advertiser full value for his money.

Treasure for Future

WE DELIVERED in September what had been promised in August, viz., a super feature on figuring multicomponent extraction by Prof. Edward G. Scheibel. Now in October we again are pointing with pride to this outstanding paper which is receiving many accolades because of its current and future reference value. Entitled "Now, a New Method to Figure Multicomponent Extraction" you readers who get personal copies of PETROLEUM REFINER likely already have read, torn from the book, and filed it for future use. Other process people, it may be said here, won't be left out entirely because reprints have been made of the 20-pager and are now available. The cost is 50 cents per copy and our advice is to get your order off promptly to Reprint Department, PETROLEUM REFINER, Box 2608, Houston 1, Texas. It's an article that will prove its worth many, many times.

Another Look Ahead

THE PROS TELL US that football teams lose many a title by worrying about a bowl bid before the seasons' schedule has been played. As for PR, October and its Materials of Construction Special Report is out of the way (see Page 98); so maybe we can with safety refer to the upcoming November issue, PR's big Petrochemical Handbook. Besides 100 process flow charts there will be authoritative articles on the overall petrochemical outlook, synthetic detergents, pesticides, synthetic fibres, plastics, aromatics, olefins, fluorochemicals and rubber. As we have advised before: Protect your individual copy of the Handbook by advising your "lend me" friends to mail their subs right off so that they can start with that issue. A handy card faces Page 3.



CONDENSER AND HEAT EXCHANGER CLINIC

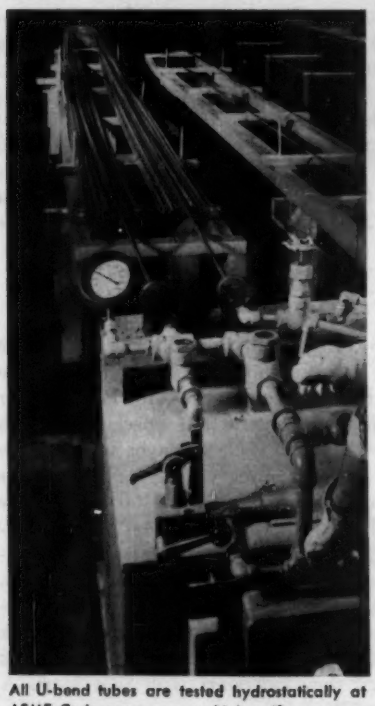
Edited by David S. Hibbard, Metallurgical Engineer
The American Brass Company, Buffalo 5, New York

New controls and services meet increasingly critical requirements in heat-transfer units

As steam cycles in turbines become more complex—and operating temperatures and pressures rise—the job of the heat-transfer equipment becomes increasingly critical. Nuclear energy plants place tremendous emphasis on continuity of service for even conventional components like condensers. And in many processing plants the cost of shutdowns may range from exorbitant to disastrous.

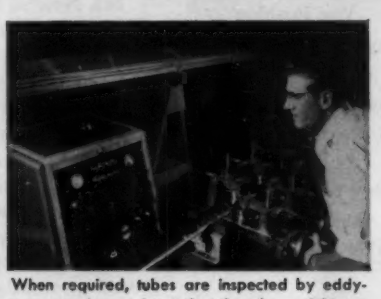
Assurance that tubes will meet service requirements becomes increasingly important. And The American Brass Company has augmented its normal quality controls with tests and services to help makers of heat transfer equipment prevent possible trouble before it starts.

Electronic inspection. All tubes are inspected visually one at a time, both internally and externally. However, where greater assurance is required, the tubes—in straight lengths up to 100′—can be inspected electronically by eddy-current equipment.



All U-bend tubes are tested hydrostatically at ASME Code pressures—or higher, if necessary.

All tubes are inspected visually one at a time, both externally and internally.



When required, tubes are inspected by eddy-current equipment, located at the tube straightener.

Hydrostatic testing. As most U-bend tubes are used in applications involving high temperatures and pressures, all of these tubes are tested hydrostatically—after bending—at ASTM Specification pressures. They can, however, be tested at ASME Code pressures, up to 6000 psi, on request, if the tube size is such that it will withstand the pressure.

Relieving stresses. All U-bend tubes, other than copper, are annealed at the bend area after bending, to eliminate the hazard of stress-corrosion cracking which might occur in service due to stresses that may exist as a result of the bending.

Duplex tubes are widely used in chemical plants and petroleum refineries to meet diverse combinations of corrosive action and/or pressure and temperature. Recently designers have selected them for use in air-removal sections of electric-power-plant condensers where corrosion is very severe.

Broadest service. In helping manufacturers and users of heat-transfer equipment meet day-to-day problems, The American Brass Company has a broad background in the latest developments in heat-transfer equipment's expanding role. And with new mill equipment now in place, it offers the broadest service available in tubes for heat-transfer equipment. For technical assistance in special problems, write: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. 5068 Rev.

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Quick Look at Industry...

Oil Mergers Hit Snags . . .

Two of the biggest mergers to hit the oil scene in a long time called off—at least temporarily. Texaco abandons plans to join with Superior because of Justice Department opposition. Texaco officials contend, "distinguished antitrust and trial counsel" fully approved legality of transaction, but Justice Department held firm on promise to begin injunction proceedings if companies attempted to merge. At best, would mean several years of litigation.

Tidewater and Skelly Oil also called off plans to merge. Said Tidewater Pres. Getty, "The continuing improvement in operating results, the excellent net assets value indicated for Tidewater by merger discussions and by outside appraisers' evaluations, show that in fairness to Tidewater stockholders, a merger under current market conditions is not advisable."

UOP Announces New Process . . .

UOP announces new catalytic hydrodealkylation process, Hydeal. Developed in conjunction with Ashland Oil, Hydeal enables refiners to produce, for chemical use, benzene from such feed stocks as toluene, xylenes and heavier aromatic mixtures.

Whiting Ordinance May Play Strike Role . . .

City Council at Whiting, Ind., passes new ordinance listing safe operating standards for inflammable businesses—could prevent Indiana Standard supervisors from operating plant in event of future strike. Ordinance is direct result of recent strike when skilled supervisory personnel ran plant at about 50% capacity. President of striking union sought council action to stop operations on grounds community safety was imperiled. Result: the new ordinance!

Panning the Washington Scene . . .

Ending longest session in 8 years, Congress adjourned leaving oil more or less unscathed except for bill hiking federal gasoline tax to 4 cents a gallon for 21 months. However, watch for stepped-up action on imports, depletion, fuels policy studies, and natural gas controls during 1960 presidential election year . . . Percentage depletion hearings postponed from Nov. 12 to Dec. 1 when 10 panelists will discuss oil discovery and development costs . . . Rep. John Blatnik's (D-Minn) public works highway investigating subcommittee will study asphalt vs. concrete in connection with interstate highway system.

Venezuela Blasts U.S. Policy . . .

Weekly bulletin of Venezuelan ministry of mines and hydrocarbons blasts U.S. Interior Secretary Seaton for "localists viewpoint" and indifference to international problems of oil industry. Warns Seaton his attitude could affect U.S. relations with friendly nations.

Engine Cylinders Getting Different Fuels? . . .

Researchers add another consideration to formulation of motor fuels. Gasoline components boiling at low and high ends not being distributed evenly among auto engine cylinders. Thus, one cylinder may get

slug of low quality fuel from otherwise satisfactory blend. What's the answer? Either design better carburetors, or devise gasoline blends having high octane material throughout boiling range.

Texaco Fuel Develops More Thrust . . .

Texaco claims new jet fuel has 135 luminometer number and higher compared with 45 to 65 luminometer numbers for conventional jet fuels. Fuel has extremely low luminosity, or formation of incandescent molecular fragments when burned. One result: burning with less heat radiation. Thus it burns at higher temperatures without overheating engines, yet still develops greater thrust (see page 250).

Possible Hike in TEL Content? . . .

U.S. Surgeon General Burney contends industry can hike TEL content of gasoline to 4 cc a gallon without increasing danger to public health. But added that refiners must take certain precautionary measures in making such a move (see page 251). Los Angeles County air pollution control officer views this with alarm—says increase could double TEL content of L.A. air within 14 years.

Argentina O.K.'s Construction Projects . . .

Argentine government puts seal of approval on petrochemical plant construction by Texas Butadiene and Chemical and Chemical International at Puerto de Seado, Santa Cruz province. Will make 15,000 tons carbon black, 30,000 tons butadiene, and 40,000 tons synthetic rubber yearly. Also O.K.'s new $21-million refinery for Shell at South Dock, Buenos Aires.

New Uses Seen for Oil . . .

Possible now for asphalt film to alleviate dust bowl conditions by stimulating grass growth in arid areas. Technique prevents excessive moisture evaporation from ground. Another agricultural use of asphalt calls for covering alternate strips of dry land with thin coatings of asphalt—rain runs off waterproofed strip to acreage which needs cultivation.

Quick Look Around the World . . .

East German imports of Russian crude expected to reach 27,700 bpd this year. Compares with 22,000 bpd in '58 and 19,500 bpd in '57 . . . Frontier Refining, Denver, buys control of Western States Refining which has 4,000-bpd plant at N. Salt Lake City. Price: $5 million . . . Refiners, including integrated companies reported $621 million profits for second '59 quarter—up $118 million over like period in '58 . . . Mobil Oil International sets up new company, Mobil Oil de Chile, at Santiago . . . Latest prediction says oil will peak at year 2000 when about half of world's petroleum supply is exhausted . . . Indiana-Standard employes still on strike at Sugar Creek, Mo. as are Amoco workers at El Dorado, Ark. and Texas City.

Another Step Toward Aromatic Control . . .

Closed-loop control now using chromatography. Once considered too slow at 10 to 30 minutes, chromatographic analysis time now slashed to 1 minute or less. Quick acting valves furnish the answer as Phillips Petroleum uses technique to maintain single component control on streams from depropanizer and furfural absorber.

Tough Row to Hoe for Plastics . . .

Plastics may be in position to get toughest job in rocketry. Already used in nose cones, insulation and body structure for rocket motors, plastics now being tested for most punishing position of all—the rocket nozzle.

BUELL PUTS "DOUBLE EDDY" TO WORK TO INCREASE CATALYST RECOVERY EFFICIENCY!

Ordinary cyclones provide limited efficiency in recovering catalyst within reactors or regenerators because of "double eddy" currents inside all cyclones. But Buell Cyclones make the Double Eddy work to increase efficiency.—The Double Eddy circulates vertically inside cyclones, acting against the normal separating force of the spinning stream of dust and vapor. Buell Cyclones have a narrow "Shave-off" port (2) at the top of the casing. This port catches and removes dust trapped in the Double Eddy. It makes the cyclone more efficient instead of less.—This is one of the reasons Buell has more experience with fluid bed catalyst recovery, for example, than all other collector manufacturers combined.—Only Buell Cyclones combine high efficiency with large diameter. They will not clog or plug even with dust loadings up to one pound (7,000 grains) per cubic foot of gas. They can be made of any material. They can be completely lined, inside and out, against heat, corrosion and abrasion. No field-fitting is needed: they are completely assembled and match-marked before shipment.—For a list of installations near you, a copy of our Catalog 103, or other information, call our nearest representative, listed in the telephone classified directories of most major cities under "Dust Collection Systems". Or write Dept. 21-J, Buell Engineering Company, Inc., 123 William Street, New York 38, N. Y. (Subsidiary: Ambuco Limited, London, England.)

1. Inlet for dust-laden flue gas.
2. Dust Shave-off port.
3. By-pass dust channel.
4. By-pass re-entry opening.
5. Dust outlet.
6. Clean flue gas outlet.

EXPERTS AT DELIVERING EXTRA EFFICIENCY IN DUST RECOVERY SYSTEMS • Cyclones • "SF" Electric Precipitators • Combination Systems • Dry Classification Systems

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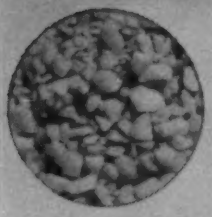
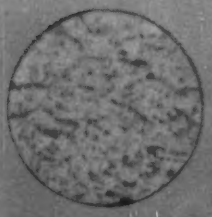
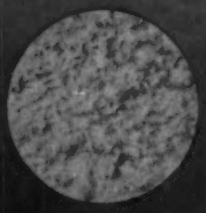
OUTSTANDING FORMS!



FLAKE. Recently developed for users requiring a product that always flows freely. Dissolves rapidly. No extra cost!



REGULAR GRANULAR. Fast dissolving, yellow-white, crystalline material for a wide range of applications.



45-S GRANULAR. Similar to regular granular form, but preferable when greater resistance to caking in storage is desired.

OUTSTANDING PRODUCT!

U.S.P.

All three forms of anhydrous Solvay® Sodium Nitrite are top quality—U. S. P. All are available in 400-lb. and 100-lb. fiber or steel drums and 100-lb. bags.

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Sodium Nitrite • Caustic Soda • Calcium Chloride • Chlorine • Chloroform
Caustic Potash • Potassium Carbonate • Sodium Bicarbonate • Soda Ash
Ammonium Chloride • Methyl Chloride • Ammonium Bicarbonate • Vinyl Chloride
Methylene Chloride • Cleaning Compounds • Hydrogen Peroxide • Aluminum
Chloride • Mutual® Chromium Chemicals • Snowflake® Crystals • Monochlorobenzene • Ortho-dichlorobenzene • Para-dichlorobenzene • Carbon Tetrachloride

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ALLIED CHEMICAL CORPORATION
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Please send without obligation sample or samples as follows:

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- ☐ Include prices and name of nearest dealer

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Address_____

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Today's Story of Cain and Abel

NO DOUBT OIL MEN by now are pretty well convinced that there is no one broad cure-all for public relations ills. So, the oil industry has just about given up waiting for that one man to come along with some wonderful formula which will completely rebuild and maintain oil industry prestige. Oil men should realize that public relations efforts are going to have to start at the very top of each oil company and organization and extend down to the very last employe. And equally important is that these efforts will have to be both continuing and diversified—as opposed to a sporadic charge of energy every time we get the urge.

However, let us digress for just a few paragraphs to sound one single note of warning.

It only stands to reason that before our industry can hope to sway public opinion to any degree, we are going to have to present a solid and unified front on all issues. Members of this industry are going to have to stop slitting each other's throats and knifing each other in the back on issues where they don't agree. In short, we must stop this modern day epic of Cain and Abel.

You know, the man who first said, "United we stand—divided we fall," wasn't just sitting around trying to think up a catchy phrase—he was concerned about his own skin. And he who first uttered, "We must all hang together—or we will surely hang separately," had only one thing on his mind—survival.

Hang Which Way? So it will have to be with the oil industry. For just as surely as you are reading these words if we don't hang together, we'll surely hang separately—and we'll hang from the yardarm of complete governmental control—a yardarm constructed by an industry which was so busy squabbling internally that it did not have the strength and fiber to ward off attacks from external foes.

Perhaps, though, you feel that we are making an editorial mountain out of a molehill or two. Think so? Then obviously you weren't around during the recent battle over mandatory control of foreign oil imports in this country. It was producers telling Congress and the general public one story while refiners and importers told another—and, after a while, the marketers got in on it too. As a matter of fact, in talking of this unhealthy situation, Edward Steinger, President of Sinclair Oil said:

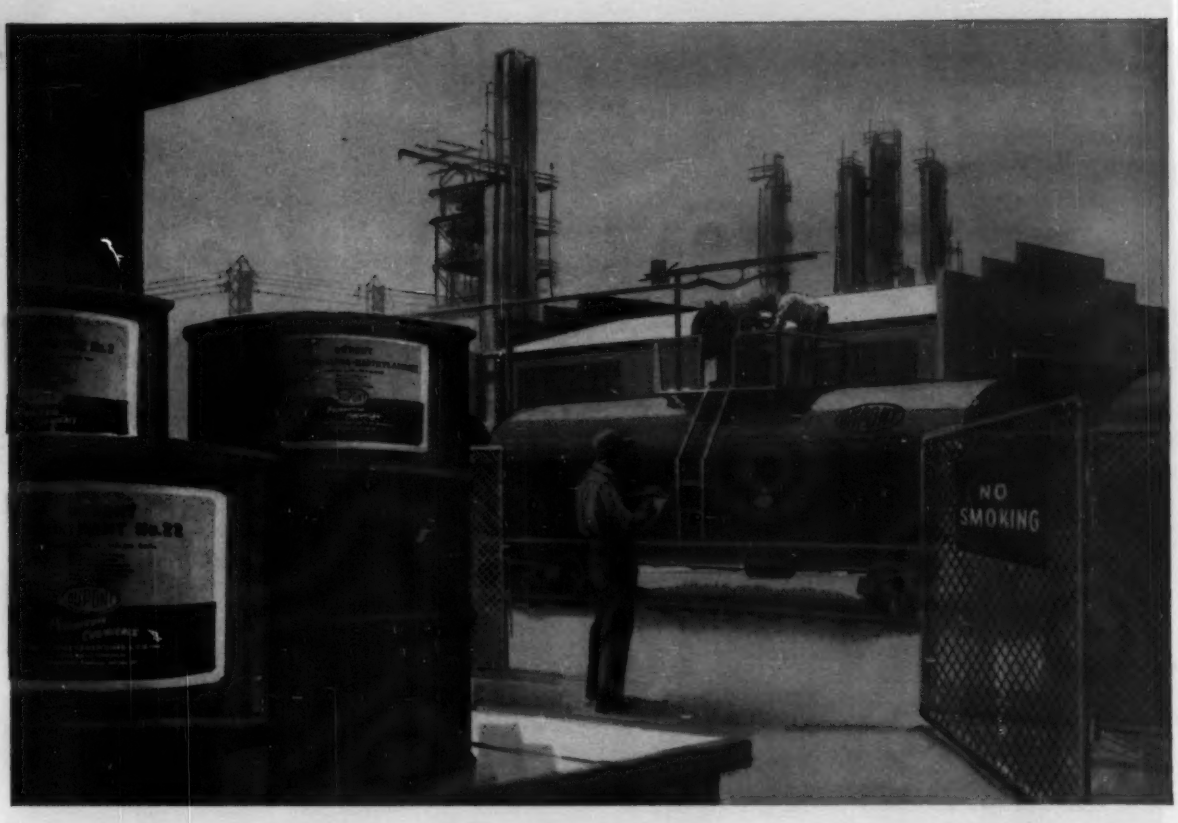
"Conceived in controversy, the unhappy mandatory imports program is now producing intra-industry demands for vengeance and retaliation. Chief among these are the curious assertions by spokesmen of some organized element in marketing that the producers must be punished for their actions by reduction or elimination of provisions for percentage depletion. The proponents of this strange theory compound confusion by adding that they do not attack, but rather endorse the principle and practical results of depletion. They simply want to get even. Sampson, too, got even by pulling down the pillars which crushed him as well as his enemies."

Want another example? Try this.

Pointing the Finger. At a recent meeting of the Texas Mid-Continent Oil & Gas Asso., a leading independent charged that mismanagement of petroleum inventories has brought domestic oil producing to the brink of liquidation. Producers had better find a remedy for the "inability" of refiners and marketers before "the domestic industry as a whole passes out of existence," was his advice. He then narrowed his sights and stated that the responsibility of the producers' plight is not a collective one, "but rests in the hands of about 30 of the nation's major companies."

So it goes, producers against refiners—marketers against producers—an industry torn by strife and name calling. But does it end here? Hardly! For when the different segments do see eye to eye, then entire oil companies band together and square off for a knock-down drag-out.

Remember how it was in California a couple of years ago in that battle over the oil and gas conservation act? They lined up like this. On one side were Richfield, Shell, Tidewater, Texaco, California-Standard, General Petroleum, Ohio Oil and Conoco. Posed against this worthy bunch were Union Oil, Consolidated Oil, Signal, Hancock, Monterrey and most of the independents. This really turned into a bloody battle in which hogs, spiders and octopi were used in newspaper ads and on billboards to depict members of the opposition. One side even claimed, "oil money supports the Arabian slave trade," and "a



A complete line of additives . . . a complete line of services—YOU GET BOTH FROM DU PONT

ADD OCTANE NUMBERS at lowest cost with Du Pont tetraethyl lead. Du Pont refinery technologists can help you adjust operations to get the highest octane rating by the least expensive methods.

IMPROVE FUEL OILS—even heavy residual stocks. Du Pont Fuel Oil Additive No. 2, a stabilizing and dispersing agent, will reduce storage tank sludge and increase operating efficiency at minimum cost.

IDENTIFY GRADES, meet legal requirements, or add a distinctive personality to your gasolines, greases and other petroleum products, with color. Du Pont's wide experience in petroleum dyes and the general field of color can help you get best results.

PREVENT OXIDATION in gasolines with Du Pont antioxidants. Full range available—AO-5, AO-22, AO-29—plus Du Pont technical service to help you get optimum effectiveness at low cost.

STABILIZE GREASE with Du Pont's "Ortholeum" 300 Grease Stabilizer, which offers the combined advantages of a metal deactivator and an antioxidant, keeping grease at top performance for extended periods.

Also:

Du Pont Metal Deactivator, to avoid harmful effects of soluble copper in all distillate fractions.

Du Pont Metal Suppressor, to keep copper out of solution by coating copper or alloy surfaces contacting stock. Supplements Metal Deactivator.

Du Pont Lube Oil Additives for dispersing, and improving quality of crankcase and industrial oils.

Du Pont DMF Antistall Additive for gasolines, to prevent stalling from carburetor icing.

Du Pont RP-2, the three-purpose gasoline additive to prevent rusting, icing and accumulation of deposits in the carburetor throat.

WAREHOUSING SERVICE on additives assures fast and constant supply of all the products mentioned above. Seven warehouses with ample supplies in strategic areas.

RR SIDING SERVICE ON TEL—There are now twenty-three points from which you can get emergency shipments of Du Pont tetraethyl lead. Ample supplies of both motor and aviation mix always ready to roll.

IN-PLANT AND DEALER SERVICES Your Du Pont representative can tell you of the many other services provided, such as market surveys, dealer training aids, safety programs, and process studies.

Call your Du Pont representative, or write to the address below for assistance in selecting the right additives for your products. E. I. du Pont de Nemours & Company (Inc.), Petroleum Chemicals Division, Wilmington 98, Delaware.

DU PONT

Better Things for Better Living . . . through Chemistry

Tetraethyl Lead and other Petroleum Additives

vote against the bill is a vote against human slavery."

Some estimated that oil companies spent more than $5 million in campaigning for and against the measure. However, no matter which way the vote went, the oil industry lost because the viciousness of the campaigning on both sides wiped out all the good will the industry had spent years in building.

It would not be difficult to come up with other specific examples where one segment of the oil industry had been against another—where one company or group of companies has tried to undercut another—our modern-day epic of Cain and Abel.

Call for Reasoning. But let's just stop for a moment and do a little reasoning. As said before, there has been an awful lot of talking about oil industry public relations and what can be done to improve it. But doesn't it just stand to reason that we ought to devote some top management time and talent to getting our own house in order? Without a solid and unified front do we stand much of a chance in convincing people that the oil industry is not the blood-sucking, money-mad monster pictured by many?

This is not to say that there won't be some differences within the oil industry between companies and the different segments. However, let's just try to be a little more prudent in going about solving them. It doesn't do any good to air our dirty laundry for all to see—this just offers more propaganda material for anti-oil interests.

And, as you finish reading this, let your mind pause to think about these family troubles of ours and how we can go about remedying them. Needed is a prescription for curing our internal ills ourselves. Should you decide that the only way to settle such disputes is to fight them out publicly, then please pause once more to reflect on what happened in the original Cain and Abel story. Remember . . . one was slain and the other was banished from the land.

A Repeat: The Insecure Lion

WE THOUGHT Union Oil Company did a mighty smooth selling job in a piece of copy that recently appeared in several well known news magazines. The effort wasn't to promote any Union product like gasoline or jet fuel or asphalt but rather to get across to the reader that to be free one must be independent; and to point out the dangers that lurk when "security" is overemphasized. We have not asked Union's permission, but we are sure they won't mind PETROLEUM REFINER's readers being included among those exposed to this powerful message on Americanism:

THE INSECURE LION

. . . who prefers his cage to freedom

A California newspaper recently carried a story about a lion that escaped from his cage during a carnival.

Men showed their heels. Women screamed and shielded their children.

Now you'd expect an escaped lion to bolt for the tall grass. But this king of beasts had been in captivity so long, he took a quick look at the world and then turned and walked back into his cage.

Obviously, security was more desirable to the lion than freedom.

His behavior demonstrates that to be free you must be independent.

When people over-emphasize security—or dependence—they can't help but lose some of their initiative. You see it in the way people more and more rely on government instead of on themselves.

It would appear that people don't realize that whatever they get from the government must eventually be paid for by them or their children. This type of "security" may be easy to take at first. But it is habit-forming; after a while, people may prefer this false security to freedom.

Then, like the lion, they walk back into their cage.

Absolute security under government is illusionary. For the only thing that government can give to the people is that which it first takes *from* the people.

A Matter For the Nose

"A LOT OF PEOPLE are complaining because Jim Carey wrote a hot letter to the anti-labor Congressmen, criticizing their votes on the labor bill and promising to try to defeat them," says an editorial in a recent issue of the "Oil, Chemical and Atomic Workers News."

"Everyone is entitled to his own opinion as to whether or not Carey would have been more influential if he had used softer words. But the people who claim that his letter was improper forgot something about democracy. A key part of our democracy is the uninhibited freedom of the people to sound off about public officials. This reminds them that they are our servants, we are not theirs.

"We think it is still good red-blooded democracy in this country to use harsh words against public officials whenever the notion strikes us. The notion strikes us right now. Therefore, we say:

'Most Congressmen stink!' "

If the editor of the OC&AW News would think back, he would find that no one thought ill of Mr. Carey for his criticism of some of our congressmen. After all, just about everyone writes a letter to his congressman at one time or another, commending or criticizing some action. It just stands to reason that these representatives cannot please each of their constituents on every single issue.

What the majority of Americans found objectionable and distasteful in this case were the Carey threats and innuendos. Most people felt that here the labor spokesman certainly overstepped his bounds.

Be that as it may, however, we are pretty sure that in his statement, "Most Congressmen stink," the editor didn't really mean that they are repugnantly odiferous. We rather believe that these words are like those of a small boy who kicks and screams and makes all kinds of dire threats when mommy won't buy him something he wants. Had Congress passed an ineffective milk-sop type of labor bill, this same editor would have been talking less about congressional "stink" and more about the "sweet smell of success."

How to handle TEL susceptibility in linear programming of gasoline blending studies

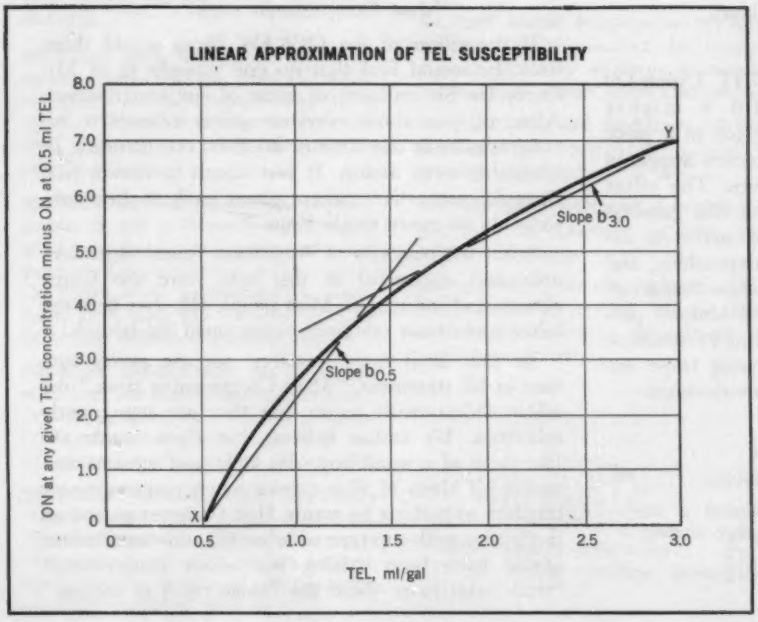
By Dr. W. C. Healy, Jr., Supervisor of the Mathematical Analysis Section,
Refinery Technology Division, Ethyl Research Laboratories

In past years, gasoline blending was comparatively simple. An engineer could establish optimum blends for two grades of gasoline by using a slide rule and a TEL response chart.

Today gasoline blending and establishing maximum antiknock effectiveness are much more complex. Many components are used to make numerous grades of gasoline. Often, market conditions divert some gasoline component to another product. All this presents the refiner with a giant-sized problem of blending for maximum profit.

The magnitude of the problem has forced the refiner to electronic computer solutions, using such techniques as linear programming.

Because TEL susceptibility is a non-linear function, it presents a special problem for computer studies when linear programming is used. Many suggestions have been made for handling the TEL function, and one of the simplest recorded to date is outlined here.



The Ethyl method of handling the TEL function is similar to others in that a target TEL susceptibility curve is approximated by straight-line segments having fixed slopes. However, it is easier to use because—

A. No extra variables are introduced.

B. No extra upper-bounding conditions are required.

C. Set-up time is reduced.

Calculating TEL linear approximations is not difficult when final blend TEL susceptibility* is known. It becomes difficult when susceptibility is to be determined by computer. Calculations must employ approximated susceptibility values while retaining accuracy for reasonable deviations.

*TEL susceptibility is here defined as the difference between octane numbers at 3.0 ml. TEL/gallon and at 0.5 ml. TEL/gallon.

For more data on advertised products, use Readers' Service Cards, last page.

Here's How Ethyl's Method Works

For example, in the figure, two line segments are used to approximate the curve. The procedure is as follows:

A. Estimate a blend TEL susceptibility curve and then plot on rectangular coordinate paper.

B. Draw two approximating lines so that one line passes through point X (0.5, ON at 0.5) and the other line passes through Y (3.0, ON at 3.0).

C. Determine the slopes of these approximating lines, $b_{0.5}$ and $b_{3.0}$, as shown on the accompanying chart.

Then the following inequalities are required; they state that the ml. TEL per gallon shall be no less than that required on either line segment, and no greater than 3.0.

1. $\text{TEL} \geq \frac{\text{ON (specification)} - \text{(ON at 0.5)}}{b_{0.5}} + 0.5$

2. $\text{TEL} \geq \frac{\text{ON (specification)} - \text{(ON at 3.0)}}{b_{3.0}} + 3.0$

3. $\text{TEL} \leq 3.0$

Let

$X_1, X_2 \cdots X_n$ = Barrels of each component in the blend.

ON_i at 0.5 = Corresponding octane blending values at 0.5 ml. TEL/gal.

ON_i at 3.0 = Corresponding octane blending values at 3.0 ml. TEL/gal.

And $Y = (\text{TEL})(\Sigma X_i)$

Then substitute in 1 and 2 above

$$\text{ON at } 0.5 = \frac{\Sigma X_i (ON_i \text{ at } 0.5)}{\Sigma X_i}$$

$$\text{ON at } 3.0 = \frac{\Sigma X_i (ON_i \text{ at } 3.0)}{\Sigma X_i}$$

and multiply 3 by ΣX_i

These inequalities then reduce to the required linear expressions:

4. $\Sigma X_i (\text{ON spec} - ON_i \text{ at } 0.5 + 0.5\, b_{0.5}) - b_{0.5} Y \leq 0$

5. $\Sigma X_i (\text{ON spec} - ON_i \text{ at } 3.0 + 3.0\, b_{3.0}) - b_{3.0} Y \leq 0$

6. $Y - 3.0 \Sigma X_i \leq 0$

Under certain conditions the number of inequalities may be reduced to two.

Susceptibility Changes Are Compensated

Error-compensation is a built-in feature with this method since, when blend susceptibility varies (higher or lower) from the estimated value, the line segments adjust themselves to the proper portion of the new curve.

For greater accuracy, more than two line segments may be used to approximate the susceptibility curve. This requires additional analogous inequalities, but no additional variables.

Each additional octane specification calls for an estimated susceptibility curve and the statement of inequalities as shown above.

Checking the Program Before the Computer Run.

How Ethyl Research is helping you

Ethyl Research has several years' experience with linear programming as it applies to gasoline blending. This background has been especially valuable for customer service work.

The new method of handling tetraethyllead susceptibility is one example of the professional assistance available to the refiner from Ethyl.

In addition, the Mathematical Analysis Section in our Refinery Technology Division will be glad to share its experience in computation techniques with your people.

For further information, just call your Ethyl Representative. He'll be glad to arrange an appointment for you with one of our Mathematical Analysts.

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How lasting quality is Heat Exchanger

4 TESTING

(FOURTH OF A FIVE-PART SERIES)

The quality of Phelps Dodge heat exchanger and condenser tubes is continually controlled at every stage of the entire fabricating operation by a special "in-mill" laboratory. In addition, the finished tubes are given exhaustive physical, chemical and metallurgical tests to assure quality and conformance with specifications.

All physical tests, including hydrostatic, flattening and expansion tests, are performed in strict accordance with ASTM and customer specifications. In the chemical laboratory, samples of the tubes are analyzed both chemically and spectrographically to determine the exact composition and conformance to the specifications. Experienced metallurgists minutely examine the grain structure of the metal in samples of both "in-process" and finished tubes. The grain size and temper are also carefully determined.

Throughout the entire tube fabricating operation—from raw materials to finished product—quality is the keynote. That's why Phelps Dodge tubes are preferred by those who demand the finest . . . the manufacturers and users of heat exchangers and condensers.

For more data on advertised products, use Readers' Service Cards, last page.

built into Phelps Dodge and Condenser Tubes...

Finished tubes receive the hydrostatic test, a quality control check in which water is pumped into the tubes at high pressures.

Another quality control test is this multi-frequency eddy current device which helps assure flawless tubes.

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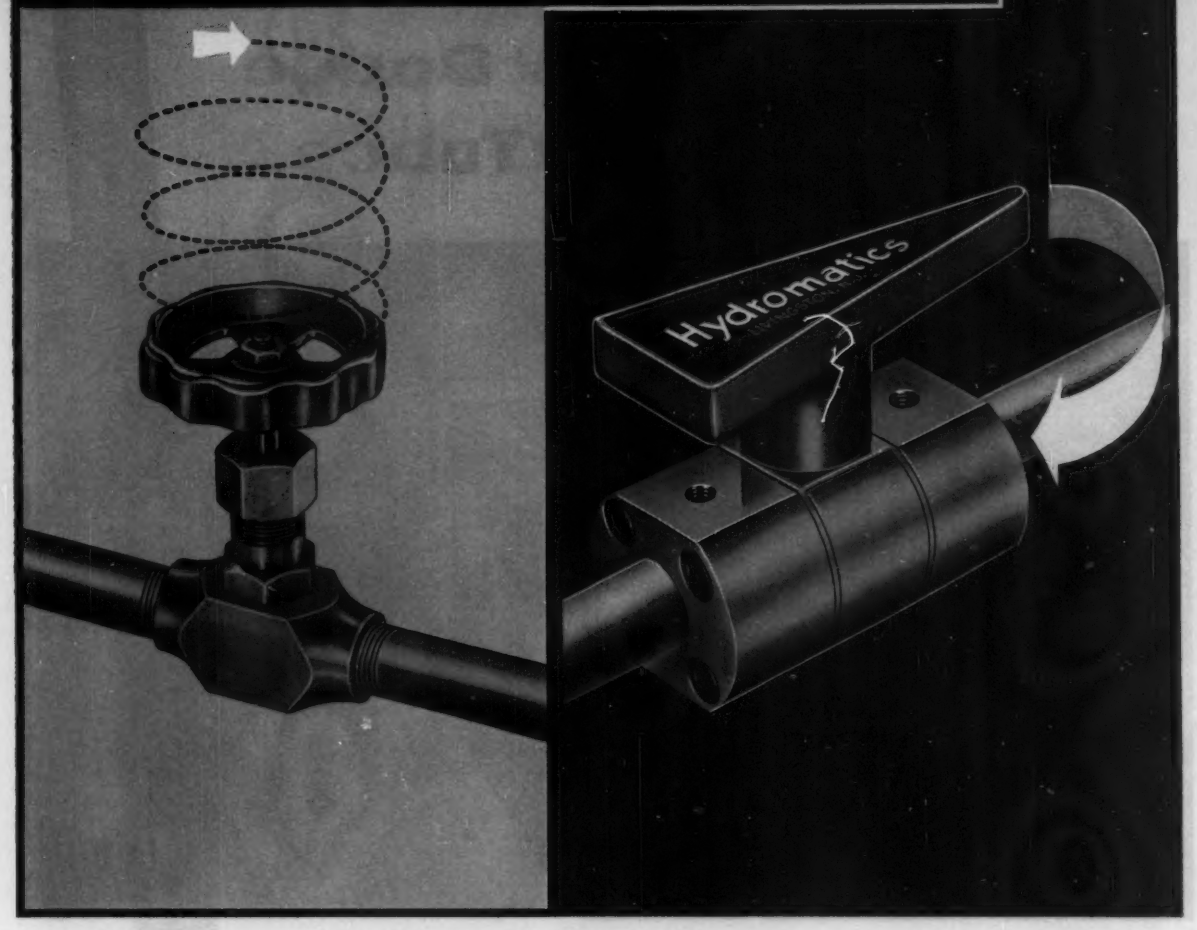
FLO-BALL 715 makes needle valves obsolete



WHICH VALVE CLOSES FASTER?

Unlike the many turns required to operate a needle valve, the Hydromatics ***FLO•BALL* 715,** shown on the right, closes instantly with a mere ¼ turn . . . **positive action** at flow pressures up to 3,000 psi with just a 4 inch-pound torque! And the arrow-shaped handle shows both open and closed positions at a glance. Exclusive ***FLO•BALL*** straight-thru design has 100% flow efficiency—more than double the flow of needle valves.

Ideal for leakproof control of air, vacuum, steam, water, fuels, oils, kerosene, alcohol, etc., the ***FLO•BALL*** features zero leakage, universal mounting, removable flanges, and all stainless steel construction.

Write today for a complete catalog describing this valve and others for corrosive and cryogenic media. Also special designs for throttling flow control.

The *FLO•BALL* costs no more than old fashioned screw-type valves!

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FLO-BALL

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Protected by L. W. Blazecrete—this structure was virtually undamaged by 2 to 6 hours of *direct* flame exposure

Protected by Johns-Manville L. W. Blazecrete . . .

vital equipment is undamaged by 3 days of explosive fire!

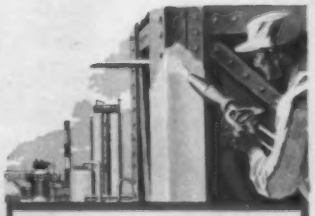
After more than seventy hours of fire and explosion at one of the world's most modern thermofor catalytic plants, damage was estimated at nearly 8 million dollars.

Yet the flames didn't destroy the entire plant. Vital equipment, key structural members and control areas . . . made fire safe by Johns-Manville L. W. Blazecrete® . . . were virtually undamaged. This simple, low-cost protection paid for itself countless times over . . . helped get the refinery back on line many months sooner.

In your plant, too, Johns-Manville L. W. Blazecrete can save you money . . . for fire control and for lining high-temperature equipment.

A hydraulic-setting refractory—Johns-Manville L. W. Blazecrete is quickly, easily applied to equipment and structural members . . . and to linings of high-temperature equipment. For troweling, just mix L. W. Blazecrete with water as you'd mix ordinary concrete—then slap trowel in place. When gunned, L. W. Blazecrete adheres readily with a minimum of rebound loss. Whether used for fire protection or for linings—L. W. *Blazecrete lasts!*

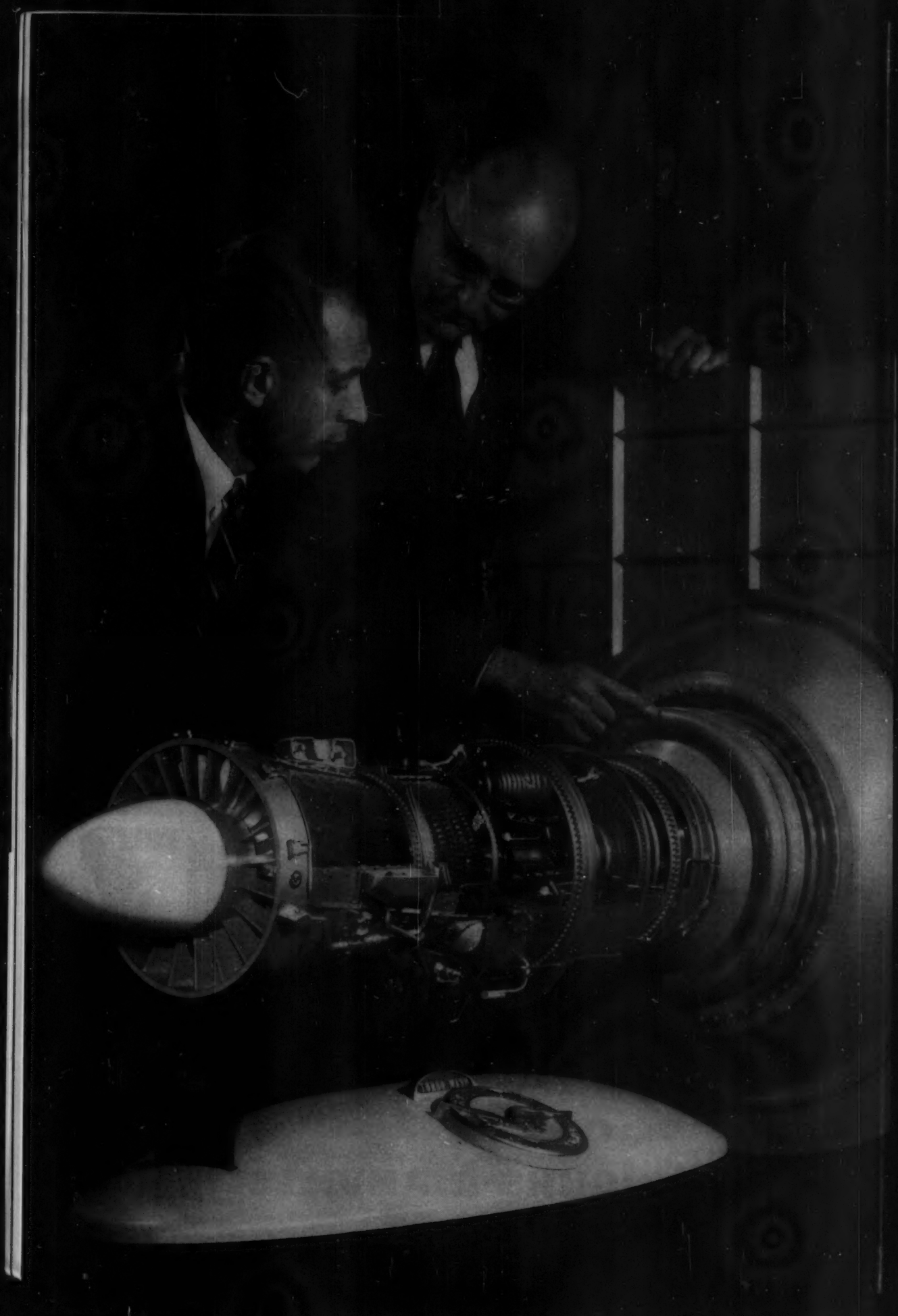
Find out more about this newest of fire protection ideas, and about the application of L. W. Blazecrete throughout the petroleum industry. Write to Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ontario.



Gunned in place or slap troweled L. W. Blazecrete is the ideal material for refractory linings. It gives you an unusually strong, dense and homogeneous lining . . . ready for use within 24 hours.

JOHNS-MANVILLE

JOHNS-MANVILLE JM PRODUCTS



Quarter scale model of experimental gas turbine being developed by Cooper Bessemer and Pratt & Whitney Aircraft. Units should be available for use within 18 months

How Cooper-Bessemer is teaming up with Pratt & Whitney Aircraft to develop JET TURBINE POWER for industry

The cutaway model shown is a revolutionary new concept in gas turbines. The generating unit is a new Pratt & Whitney Aircraft jet engine—a modification of the famous J-57 aircraft engine, designed for gas fuel. The companion power unit is a new Cooper-Bessemer power turbine. This combination, now in the advanced experimental stages, represents the hottest development in industrial power in 20 years. It will mean drastic economies in installations of engine-driven compressors, generators and other rotating machinery.

For example, in gas compressor stations, it is expected to reduce total station cost by 50%!

Plans call for this new gas turbine to be available for broad application within 18 months. In the meantime, watch for reports on further developments in this pioneering teamwork by Cooper-Bessemer and Pratt & Whitney Aircraft.

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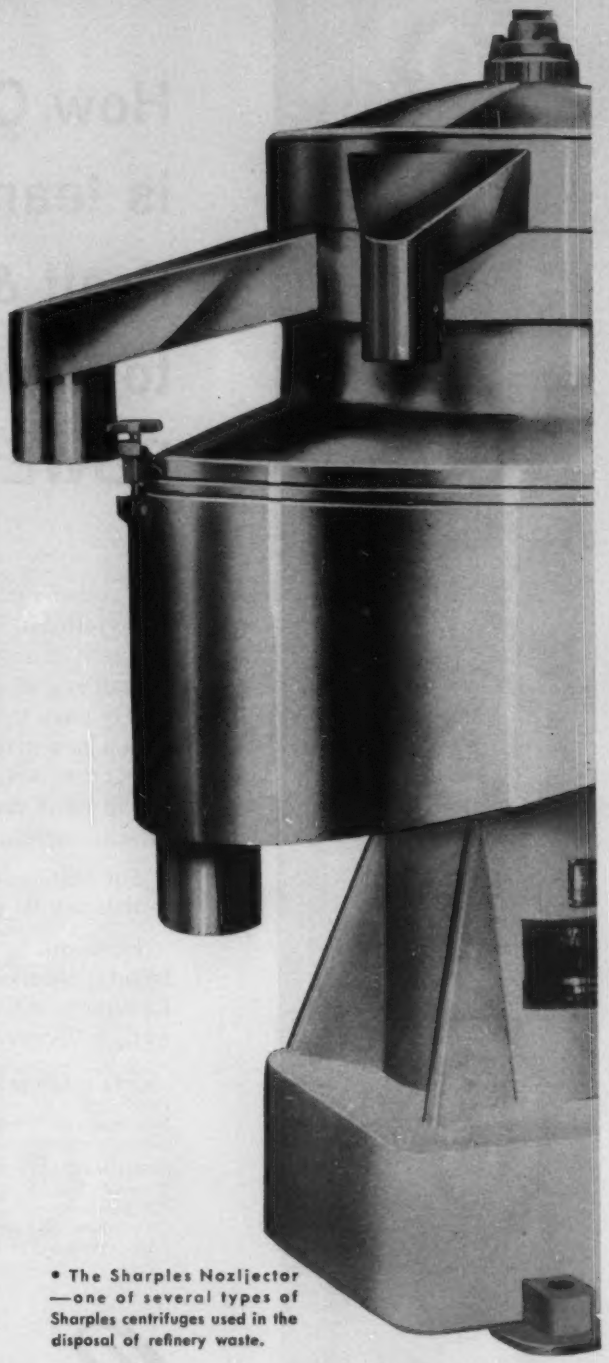
Sharples Centrifuges Are Doing A BIG JOB IN REFINERY WASTE DISPOSAL At Low Cost

- **SLOP OIL**—Sharples centrifuges reclaim oil of good quality from slop oil skimmings; the waste water stream can be purified to the degree desired for acceptance into sewer or waterway; and solids are made disposable.
- **SETTLING BASIN AND TANK BOTTOMS**—Sharples centrifuges remove oil and concentrate solids for dumping or incineration.
- **WATER TREATMENT SLUDGE**—Sharples centrifuges concentrate water treat solids.
- **CAT CRACKING BOTTOMS**—Sharples centrifuges concentrate the solids as desired and release the oil for use.

Sharples centrifuges give a quick separation of oil, water and solids, and quality of reclaimed oil is suitable for cracking or blending with crude oil. Maintenance is reasonable; operation is simple and trouble-free.

If waste disposal is your responsibility, why not get in touch with Sharples; we're doing a big job in the refinery industry.

Sharples waste disposal systems are specifically engineered to meet the requirements of each refinery. Savings possible as the result of increased recovery of oil, elimination of filter aid and chemical treats, reduction in cost of solids disposal, etc., often make this an investment with quick pay-out—including replacement of existing equipment.



• The Sharples Nozljector —one of several types of Sharples centrifuges used in the disposal of refinery waste.

THE SHARPLES CORPORATION

2300 WESTMORELAND STREET / PHILADELPHIA 40, PENNSYLVANIA

NEW YORK • PITTSBURGH • CLEVELAND • DETROIT • CHICAGO • HOUSTON • SAN FRANCISCO • LOS ANGELES • ST. LOUIS • ATLANTA

Associated Companies and Representatives throughout the World

For more data on advertised products, use Readers' Service Cards, last page.

AT PHILLIPS PETROLEUM CO.

First full-scale PENTANE ISOMERIZATION plant uses Clark Barrel-Type Centrifugal Compressor

Isomerize normal pentane to permit the use of natural gasoline as a high octane blending stock? Why not, said Phillips Petroleum Company. Normal Pentane was one of the remaining major components of natural gasoline that could be upgraded. Furthermore, the low sensitivity of isopentane together with its high octane level made it an ideal blending agent in premium gasoline.

By-passing the usual prototype size unit, Phillips built the industry's first full scale pentane isomerization plant. The plant uses Universal Oil Products Company's Penex Process employing a platinum-containing catalyst. With a design capacity of 34,400 bbl. per day of pentane reactor feed, the plant can produce about 16,000 bbl. per day of 95% isopentane. Startup was smooth and design yields were quickly reached.

To handle the hydrogen recycle phase of the process at the Borger, Texas plant, a Clark Vertically-Split Multi-Stage Centrifugal Compressor was selected. While the ratio of hydrogen to hydrocarbon is low in this process, the high feed capacity requires 2,000 hp for hydrogen circulation. As in many other similar processes, the performance of this Clark compressor has from startup met the rigid design requirements.

CLARK

For complete details on Clark Vertically-Split Compressors, write for Bulletin 150.

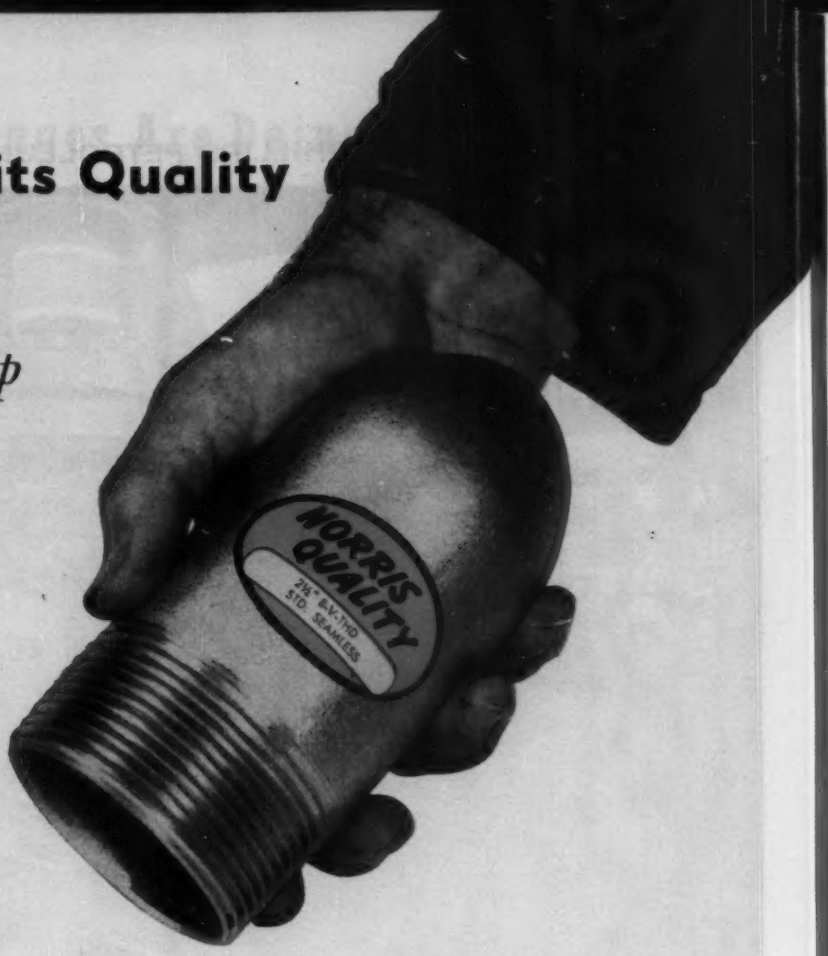
COMPRESSORS AND GAS TURBINES

CLARK BROS. CO., OLEAN, NEW YORK

For more data on advertised products, use Readers' Service Cards, last page.

You Can Feel its Quality

its balance
its craftsmanship
its durability



A Complete Line of Fittings . . .

Bull Plugs
Couplings
Swaged Nipples
Tubing Nipples
Welding Reducers
and Caps

Norris fittings are always superior to the most exacting specifications.

Made from specially selected steels and alloys.

Special application fittings of chrome and corrosive resistant steel available.

We sincerely invite you to compare.

Contact your Norris Man for complete specifications brochure or drop us a postcard . . . no obligation.

NORRIS QUALITY
TUBULAR PRODUCTS

W. C. NORRIS, MANUFACTURER
DIVISION OF DOVER CORPORATION
TULSA, OKLAHOMA

BRANCHES: Great Bend, Kansas; Corpus Christi, Houston, Kilgore, Odessa, Wichita Falls, Texas; Oklahoma City, Oklahoma; Salem, Illinois; Casper, Wyoming; Farmington, New Mexico; Edmonton, Alberta, Canada.

Buy From *Your* NORRIS Distributor

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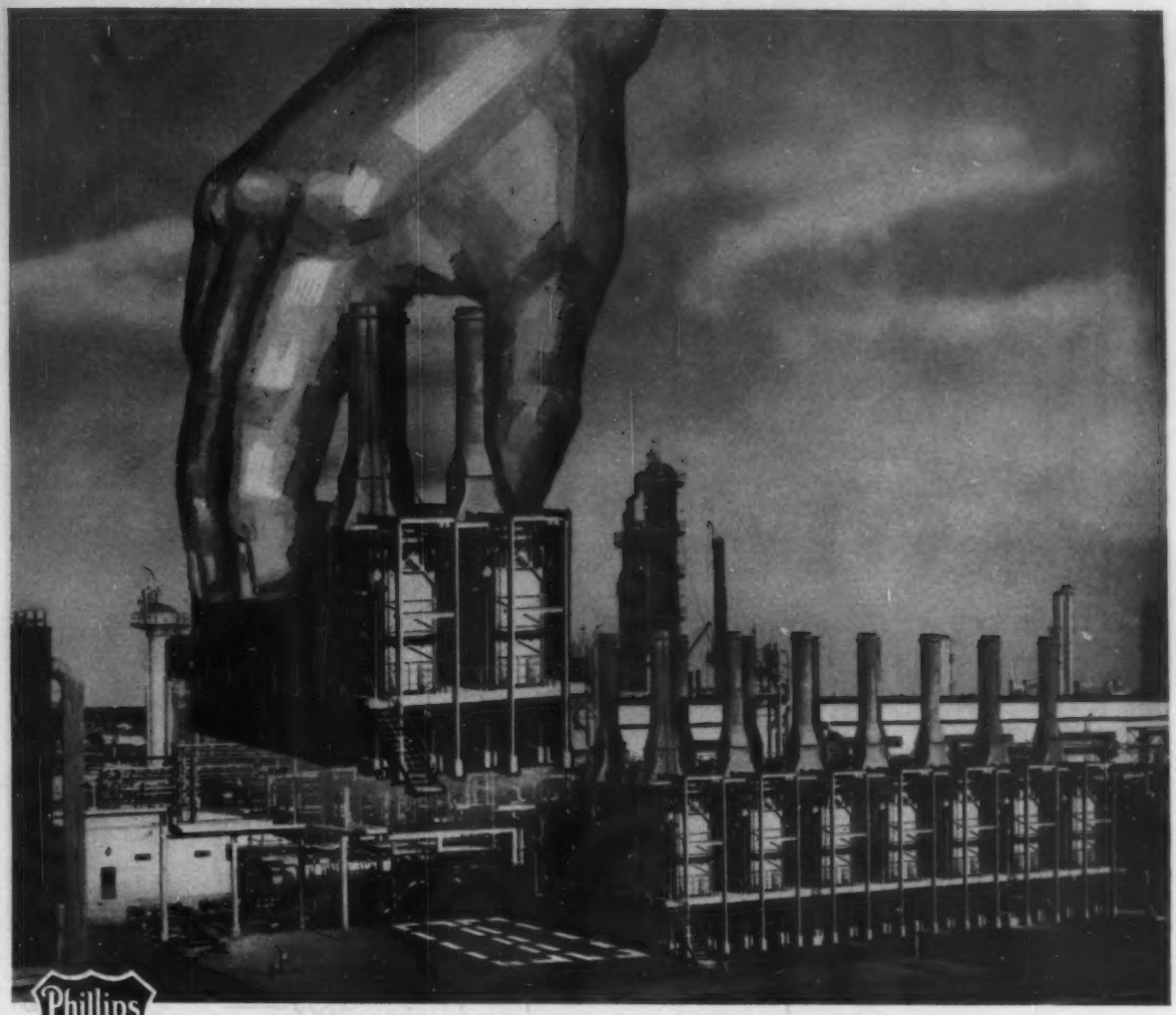


Phillips 66 again Selects Selas Gradiation® to Increase Ethylene Production

In 1957, seven Gradiation heaters went on-stream in ethylene service at Phillips Chemicals' Sweeney, Texas, refinery. Capacity: 180 million pounds per year. Today that capacity is inadequate.

To meet the booming demand for high quality ethylene Phillips has again turned to Selas . . . for two more Gradiation heaters . . . to up production by 42%.

Selas horizontal tubular heaters deliver:

- Preciseness of Heating . . . complete combustion within Duradiant® burner cup permits placing burners close to tubes . . . achieving fast heat-up, instantaneous response to controller demand.
- Heat Uniformity . . . even distribution of heat, along and around tubes, increases tube life by eliminating hot spots, minimizing coke formation.
- Versatility . . . Duradiant burners, readily adjustable to desired heat pattern, provide Zone Control which enables meeting any time-temperature curve in pyrolysis or catalytic reactions.
- High conversion and selectivity plus ability to process butane and propane feed stocks, interchangeably.
- On-stream periods, without shutdown, well in excess of 30 days.

May we arrange for a Selas field engineer to discuss your heat processing needs with you? For this service – without cost or obligation to you – or for a copy of Bulletin 710 "Gradiation Heating for Petroleum and Chemical Processing" write to Mr. K. W. Fleischer, vice president, Fluid Processing Div., Selas Corporation of America, Dresher, Pa.

Gradiation and Duradiant are registered tradenames of Selas Corporation of America

SELAS CORPORATION OF AMERICA DRESHER, PENNSYLVANIA

Heat and Fluid Processing Engineers

DEVELOPMENT · DESIGN · CONSTRUCTION

This electronic computer can help optimize your marketing, production and equipment efficiency!

Royal Precision

LGP-30

World's largest-selling engineering and scientific computer

The Royal Precision LGP-30, marketed by Royal McBee, is today helping create new concepts of operating efficiency in many processing industry applications.

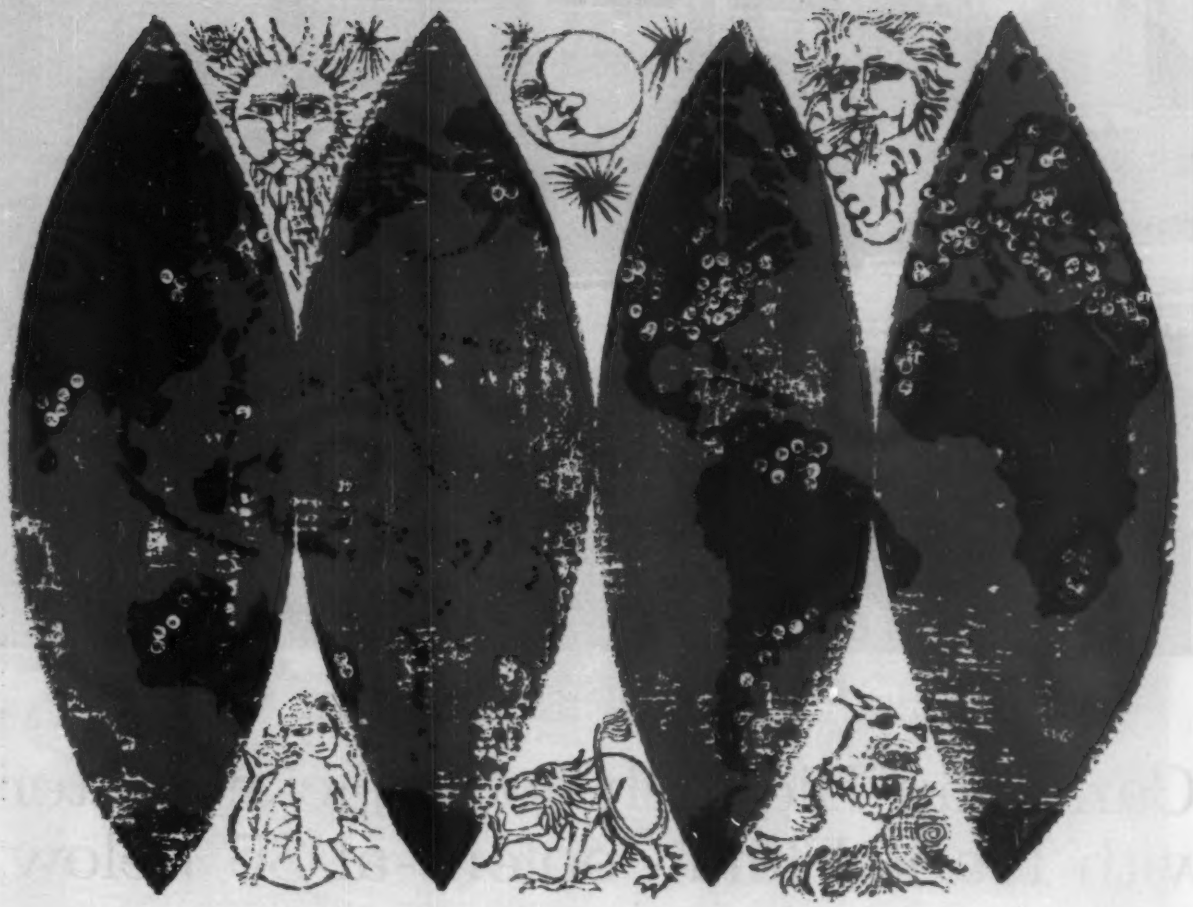
The LGP-30 is programmed and operated by the engineer himself to cut through the maze of mathematical computations demanded for peak-level operations. Some examples of the many tasks this machine is now performing are: simple selection of the severity level of the catalytic reformer; most profitable combination of operations in the production, sale and purchase of gasoline, butane, naphtha; computation of heat balances; vapor-liquid equilibria; process simulation; design of heat exchangers, columns and reactors; crude oil evaluation; product yield structure; blending; economic payout determinations.

The LGP-30 is low in cost—about the price of a good engineer—and is simple to program and operate. Its 4096-word memory is comparable to computers many times its size and cost. User-engineers develop a man-machine relationship to the point where the machine becomes an extension of their own thinking capacity. Bolder, more creative engineering almost always results.

No site preparation is necessary. Plug the LGP-30 into the nearest standard outlet and it is ready to go to work. Customers have access to an extensive library of engineering programs and sub-routines, plus the opportunity to join an active users organization.

Royal Precision Corporation

Royal Precision is jointly owned by the Royal McBee and General Precision Equipment Corporations. LGP-30 sales and service are available coast-to-coast, in Canada and abroad through Royal McBee Data Processing offices. For complete information on the LGP-30, write **ROYAL McBEE CORPORATION**, data processing division, Port Chester, N. Y.



805 reasons a Foster Wheeler plant fits your requirements best

Wouldn't you like to find your new plant running on its scheduled completion date, meeting all specifications, and at a cost within the construction budget? The process industries have come to expect results like these when dealing with Foster Wheeler.

Would you like to see your own process plants handled by designers, engineers and construction men who have successfully put 75 different processes into efficient commercial operation?

And, if you have decided to pioneer a new process, wouldn't you like to have the advantage of Foster Wheeler's long experience with basic processing methods, such as fluidized solids, effluent refrigeration, simplified sulfonation, and efficient heat balancing in chemical operations, etc. This unique experience—plus *procurement knowledge* gained in construction of some 805 large and small plants throughout the world, and *specialized equipment know-how* available through FW's own equipment division—works for you when you use FW design, engineering and construction services.

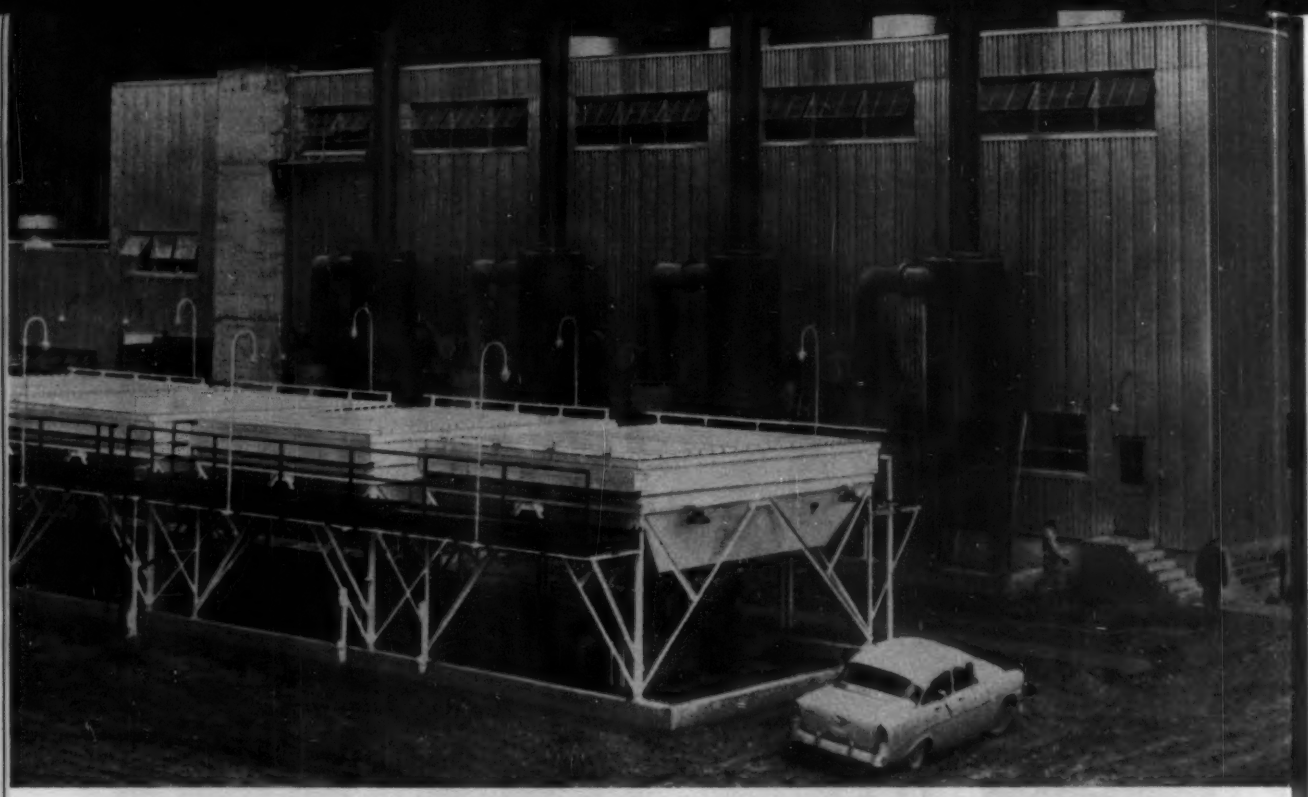
Get specific information by discussing your process needs and plant requirements with Foster Wheeler Corporation, 666 Fifth Avenue, New York 19, N.Y.—or write for a copy of the new fully-illustrated booklet describing FW's services.

Heat Engineered products, plants and processes...for the world's industrial progress.

FOSTER WHEELER

NEW YORK LONDON PARIS ST. CATHARINES, ONT.

petroleum processing chemical processing specialized installations



Twenty air cooled units like this cool engine jacket water for four Canadian "Big Inch" compressor stations. Units are designed to dissipate 8.6 MBTU/hr. from the 288 gpm jacket cooling water at temperatures from 170 to 110° with an ambient temperature of 90° F. General contractor: Canadian Bechtel, Ltd.

Canadian "Big Inch" cools jacket water with Trane Fluid Coolers - at 35° below!

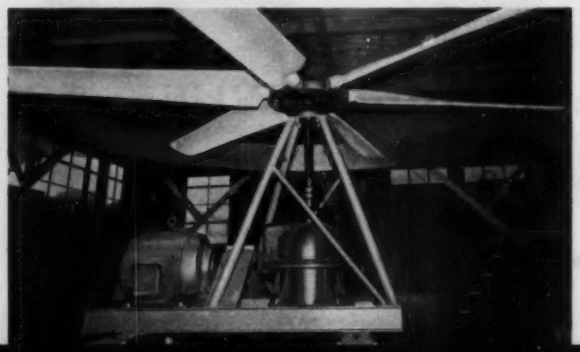
Westcoast Transmission Company's 650 mile-long, 30-inch pipeline system through British Columbia passes through country where winter temperatures are very low. Cooling engine jacket water for compressor stations along the way takes rugged equipment—coolers that can function efficiently at 35 or 40 degrees below zero.

Westcoast Transmission Company chose TRANE Fluid Coolers for this important job. Air cooling was essential at these extreme temperatures. And TRANE Fluid Coolers have shown that they meet exacting requirements under all weather conditions.

More and more major transmission companies are turning to TRANE for rugged, dependable Fluid Coolers. Many of these companies report simplified maintenance, a minimum of adjustment problems. And, with TRANE Fluid Coolers, engineers know that they can depend upon the accuracy and completeness of the capacity ratings—based upon the industry's most complete laboratory testing.

When you have a fluid cooling problem, turn to TRANE! Call your nearby TRANE Sales Office. Or write TRANE, La Crosse, Wisconsin.

The air handling segments have shutters for control of their forced vertical air flow, with variable-pitch propellers. (TRANE Fluid Coolers are also available with horizontal discharge.) 2-speed fan, motor and drive are factory-aligned on a single metal base. All framework parts are predrilled and match-marked.



For any air condition, turn to

TRANE

MANUFACTURING ENGINEERS OF AIR CONDITIONING, HEATING, VENTILATING AND HEAT TRANSFER EQUIPMENT

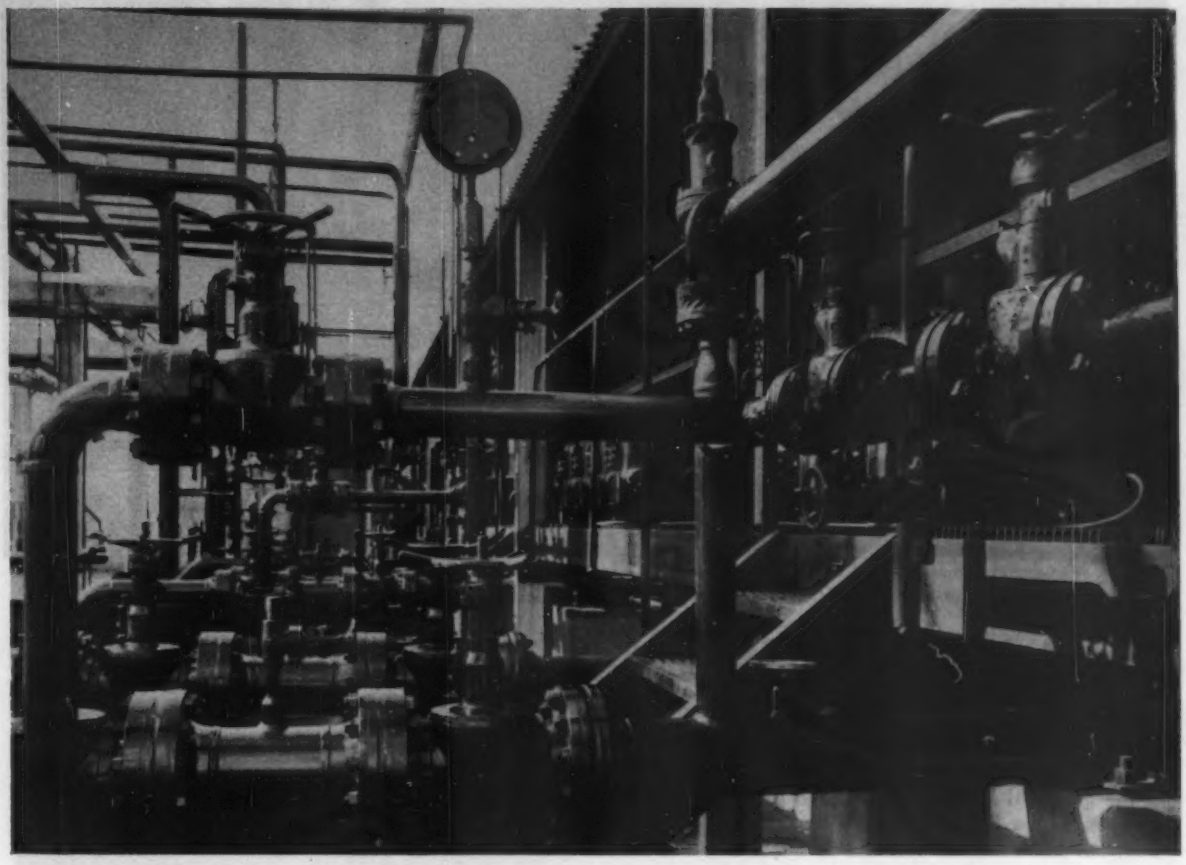
THE TRANE COMPANY, LA CROSSE, WIS. • SCRANTON MFG. DIV., SCRANTON, PA. CLARKSVILLE MFG. DIV., CLARKSVILLE, TENN. • TRANE COMPANY OF CANADA, LIMITED, TORONTO • 100 U.S. AND 19 CANADIAN OFFICES

START

USING ORBIT FORGED STEEL VALVES IN YOUR PROCESS AREA FROM FORMATION TO FINISHED PRODUCT

There are no voids or cavities in the body or bonnet of an Orbit Forged Steel Valve where pressures can build up from trapped fluids or gases when the valve is either in open or closed position. Body and bonnet is all forged steel, vapor-tight construction.

Stem packing chamber has great depth and capacity for easier adjustment and longer life of the packing. Stem packing is pliable and adjustable and can be added to or adjusted while the valve is in service and under pressure.



Orbit Valves in Typical Platformer Service Handling Recycle Hydrogen Gas at Approximately 500 psig and 100° F.

WRITE FOR CATALOG 58-B

ORBIT VALVE COMPANY

PHONE LUther 4-4761 TWX TU 925
P. O. BOX 899 TULSA, OKLAHOMA

WAREHOUSES: HOUSTON, TEXAS, 407 Velasco, CApitol 8-6623, TWX HO 115; ODESSA, TEXAS, 402 West County Road, FEderal 7-2263, TWX ODESSA TEX 8706; LAFAYETTE, LOUISIANA, 3111 Cameron St., CEnter 4-3326; CASPER, WYOMING, 414 South Elm Street, Phone 2-1324; EDMONTON, ALBERTA, CANADA, 7119-104th St., Phone 391-283. WEST COAST REPRESENTATIVES: Charles Lowe Company, 383 Fourth Street, San Francisco, Calif.; Marshall E. Niedecker Company, 2785 Cherry Ave., Signal Hill, Calif. CANADIAN REPRESENTATIVES: T. R. Pickford & Company, Ltd., Calgary, Alberta, 309 7th Avenue West; Amherst 2-7371. EXPORT REPRESENTATIVE: New York 36, N. Y., 500 Fifth Avenue, BRyant 9-2236.

ORBIT VALVES ®

For more data on advertised products, use Readers' Service Cards, last page.

Manufactured and installed by Babcock-Wilcox & Goldie McCulloch, Limited, this B&W CO Boiler uses 222,400 lb/hr catalytic gases at 600 F. These gases contain 4.6 per cent CO (by volume) plus traces of entrained hydro-carbons.

B&W CO BOILER SLASHES STEAM GENERATING FUEL COSTS FOR BRITISH AMERICAN OIL

At the Montreal East Refinery of the British American Oil Company, a B&W CO Boiler installed in October, 1957, has proved to be a sound investment. Waste CO gases, normally released to the atmosphere, are put to work to generate 60,000 pounds of steam per hour. Add to this the 90,000 lb per hour generated by the unit from conventional fuels and you have a total output of 150,000 lb per hour. No wonder British American points to this unit with pride. It saves them thousands of dollars yearly in fuel costs; furnishes a dependable supply of high quality steam that helps over-all refinery efficiency.

Similar Savings for your Refinery. By recovering sensible heat and the heat of combustibles in the waste gases, a B&W CO Boiler can mean similar savings for your refinery. In addition, B&W CO Boilers give your community relations a big assist by removing entrained hydro-carbons from waste gases—thereby helping to lick the troublesome problem of air pollution.

Find out how a B&W CO Boiler can Help you Cut Costs. These are practical advantages that can help improve your refinery operations. There are many more that add up to increased efficiency and economy. Get the complete story by writing for Bulletin G-87, The Babcock & Wilcox Company, Barberton, Ohio.

CO-10¹

B&W

THE BABCOCK & WILCOX COMPANY

BOILER DIVISION

Chemico's modern research and development center is staffed and equipped to provide industry with a full range of bench scale and pilot scale development services, including:

- ★ Process development and evaluation
- ★ New process research
- ★ Process improvement
- ★ Efficiency improvement of unit operations
- ★ Development of new equipment and products

If an idea is economically sound and technically feasible, Chemico can put it into commercial operation in the shortest possible time. Each research contract is supervised by engineers and technicians familiar with industrial processes, equipment, and designs. Therefore, the transition to profitable commercial application is smooth and efficient. The client can be assured that Chemico will undertake such activities in the framework of a completely confidential relationship.

If you are interested in learning more about Chemico's research activities, please address your inquiries: Attn: TECHNICAL DIRECTOR, at the address below.

RESEARCH

from an engineering point of view

CHEMICO

CHEMICAL CONSTRUCTION CORPORATION
[illegible] West 43rd Street, New York 36, New York

CHICAGO • DALLAS • HOUSTON • PORTLAND, ORE. • TORONTO • LONDON • PARIS • JOHANNESBURG • TOKYO

For more data on advertised products, use Readers' Service Cards, last page.

After 3 years of service, feather valves and other moving parts in air compressors show no trace of deposits or residue—still do not need cleaning.

"Cellulubes eliminate fires and explosions ... keep compressor parts clean"

says MR. T. E. DANIEL, Foreman, Cypress Compressor Station
Trunkline Gas Company, Cypress, Texas

"Since using Cellulube 220 in our air compressors we have never experienced or had any indication of fire or explosion in our compressed air systems," continues Mr. Daniel.

Installed at Trunkline's Cypress Compressor Station when it opened three years ago, Cellulubes thus provide an authoritative 7800-hour operating record that indicates not only efficient and far safer operation, but substantial savings as well. Mr. R. C. Carter, Trunkline's Compressor Department Superintendent, describes them thus:

"First and most important, of course, is the elimination of any risk to our personnel—from fire, explosion, or fragmentation. Secondly, we save on heavy equipment replacement costs, and thirdly, down-time losses.

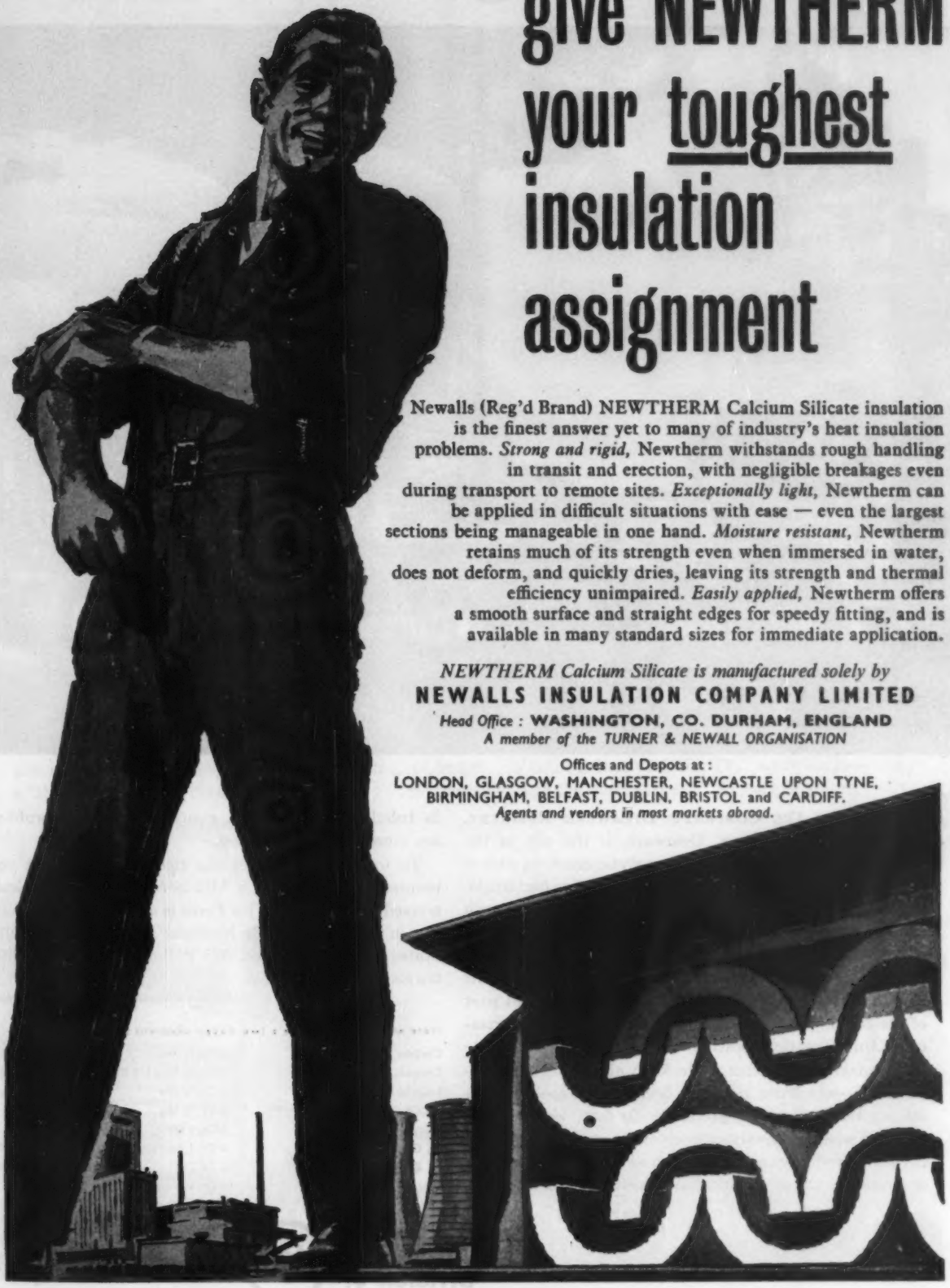
"A major savings is in preventive maintenance. Formerly, we completely disassembled and cleaned air compressors every six months. Cellulubes keep machinery so clean that this interval has been indefinitely extended, and so far we've saved at least 60 man-hours. Finally, Cellulubes never get 'dirty,' nor do they burn away by friction or compression."

Cellulubes . . . the *safe* lubricants and hydraulic fluids . . . are available in six controlled viscosities. If you'd like a sample for evaluation, please let us know the application involved.
Celanese Corporation of America, Chemical Division, Dept. 574-J, 180 Madison Avenue, New York 16, N. Y. Celanese® Cellulube®

Cellulubes... Celanese CHEMICALS **fire-resistant functional fluids**

Canadian Affiliate: Canadian Chemical Co., Limited, Montreal, Toronto and Vancouver • Export Sales: Amcel Co., Inc., and Pan Amcel Co., Inc., 180 Madison Avenue, New York 16, N.Y.

give NEWTHERM your toughest insulation assignment



Newalls (Reg'd Brand) NEWTHERM Calcium Silicate insulation is the finest answer yet to many of industry's heat insulation problems. *Strong and rigid,* Newtherm withstands rough handling in transit and erection, with negligible breakages even during transport to remote sites. *Exceptionally light,* Newtherm can be applied in difficult situations with ease — even the largest sections being manageable in one hand. *Moisture resistant,* Newtherm retains much of its strength even when immersed in water, does not deform, and quickly dries, leaving its strength and thermal efficiency unimpaired. *Easily applied,* Newtherm offers a smooth surface and straight edges for speedy fitting, and is available in many standard sizes for immediate application.

NEWTHERM Calcium Silicate is manufactured solely by

NEWALLS INSULATION COMPANY LIMITED

Head Office : **WASHINGTON, CO. DURHAM, ENGLAND**

A member of the TURNER & NEWALL ORGANISATION

Offices and Depots at :
LONDON, GLASGOW, MANCHESTER, NEWCASTLE UPON TYNE, BIRMINGHAM, BELFAST, DUBLIN, BRISTOL and CARDIFF.
Agents and vendors in most markets abroad.

For more data on advertised products, use Readers' Service Cards, last page.

Tidewater's "Refinery of the Future" uses 8,500 tons of USS National Seamless

TIDEWATER OIL COMPANY'S DELAWARE REFINERY, south of Wilmington, Delaware, is the site of the world's largest Orthoflow fluid catalytic cracking unit—a result of the revolutionary concept of using single, large-capacity units rather than multiple ones for each process in the refining operation. The purpose is to save costs—both in initial investment and maintenance.

National Seamless Tubular Products—over 8,500 tons and in sizes from 2⅜" to 24" O.D.—is an integral part of the 250 miles of oil-carrying pipelines which criss-cross this gigantic operation.

We make it our business to keep abreast of developments in petroleum refining, because we specialize in solving refinery tubing problems. In fact, we make 24 different steel tube analyses, each one *specifically developed* to combat refinery conditions such as corrosion, oxidation or pressure. Other chemical compositions are available in tubular products, and many temperature problems are presently being studied.

To make sure you get the right alloy to meet your requirements, we have a Mill Service Force technically trained to assist you. This Force is available for consultation in the field. Write to National Tube Division, United States Steel Corporation, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

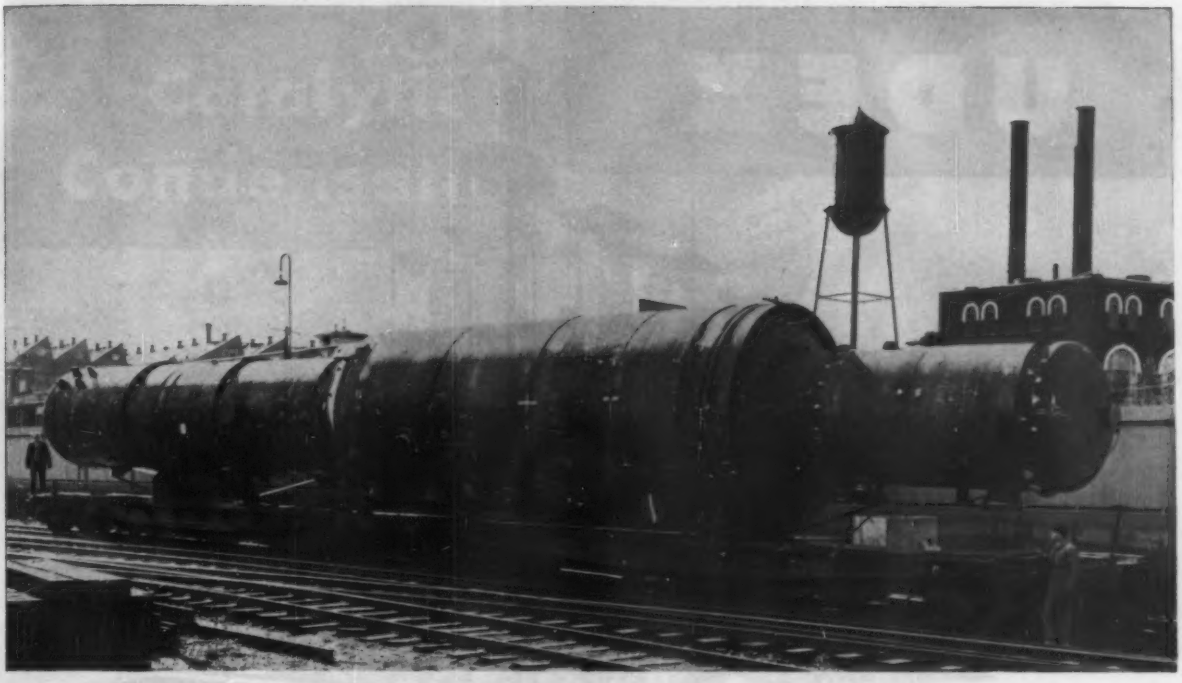
USS and National are registered trademarks

Here are National Tube's two dozen different tube analyses:

Carbon	5 Cr, ½ Mo	17 Cr
Carbon, ½ Mo	5 Cr, ½ Mo, 1½ Si	18-8
1 Cr, ½ Mo	7 Cr, ½ Mo	18-8 Ti
1¼ Cr, ½ Mo	8 Cr, ½ Mo	18-8 Cb
2 Cr, ½ Mo	8 Cr, 1 Mo	18-8 Mo
2¼ Cr, 1 Mo	9 Cr, 1 Mo	25-20
2¼ Cr, ½ Mo, ¾ Si	12 Cr	3½ Ni
3 Cr, 1 Mo	12 Cr, Al	5 Ni

National Tube Division of USS United States Steel

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors • United States Steel Supply Division, Warehouse Distributors • United States Steel Export Company, New York



VERSATILITY

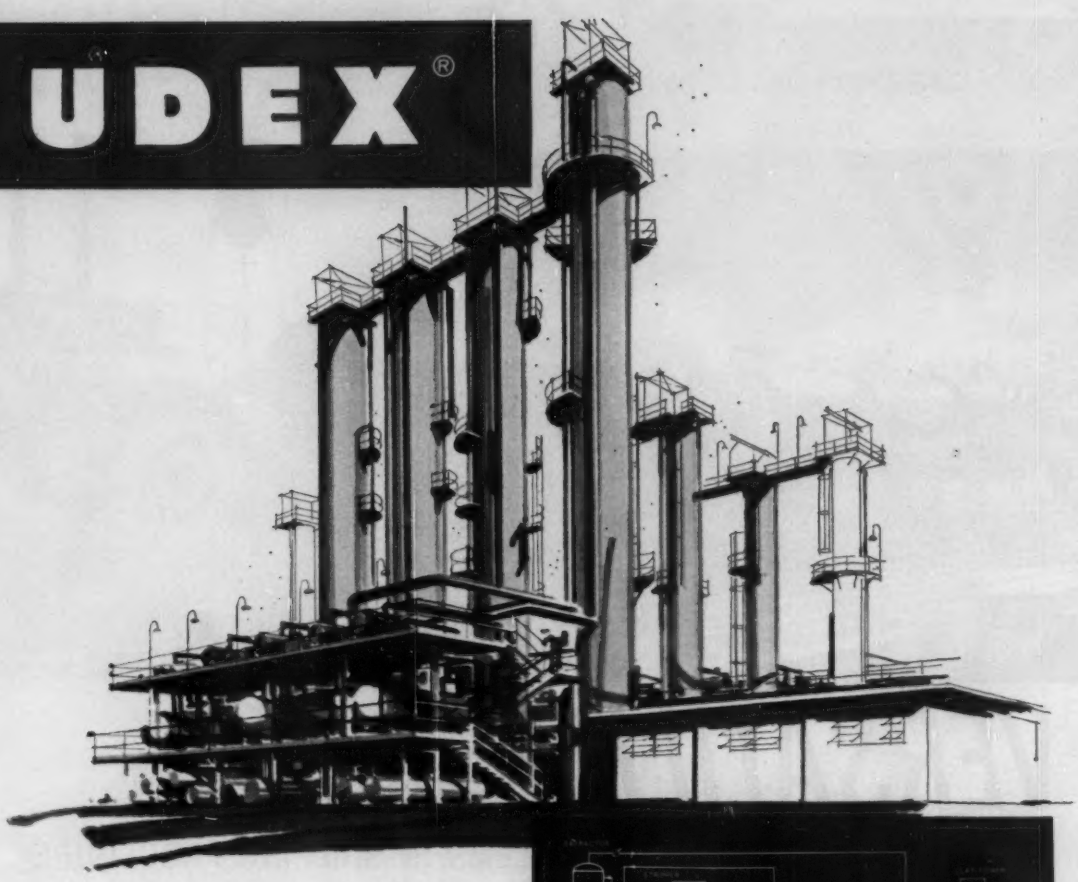
SOLVES PROBLEMS IN SHIPPING PROCEDURE

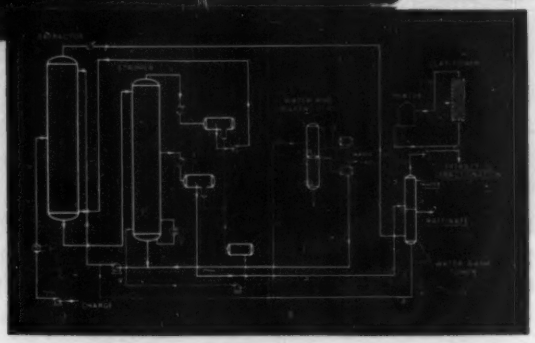
The variety of large-size work which Sun Ship's shops produce is matched by a variety of equally important shipping problems. Sun's facilities for shipping by water (overseas, coastal, or inland)—directly from our plant, are often the most economical available, and when large pressure vessels, such as those shown here, are scheduled for overseas shipment, direct, plant-to-ship loading saves additional time and expense.

Inland customers benefit from our ability to pre-check clearances and schedule shipments by rail or truck before production ever begins, so that delivery on schedule . . . on budget . . . is assured. Thus VERSATILITY . . . which has been made a "standard procedure" through Sun's experience . . . is extended through one more avenue . . . Shipping Procedure.

For more data on advertised products, use Readers' Service Cards, last page.

UDEX®





The ideal process for separation of super-purity aromatics

You can get substantial production of high-purity aromatics and still keep costs at a minimum with UOP's Udex extraction process. Udex-processed benzene, toluene and xylenes not only meet nitration-grade specifications but exceed these requirements in purity. These aromatics are produced at extremely low cost, since relatively inexpensive and readily available glycol solvents are used in the process. Utility requirements are considerably lower, too. The versatile Udex process permits recovery of aromatics from catalytic reformates, from by-product light oils produced in coke-oven operation, from thermal aromatic concentrates such as ethylene co-product light oil fractions and other aromatic-rich by-products. Although most petrochemical processors place major emphasis on recovery of benzene, toluene and xylenes, the Udex process also permits recovery of heavier aromatics and dicyclics in high purity. Udex is just one of many UOP refining and petrochemical processes available to the entire refining industry. A complete booklet on the UOP Udex process has just been published and is yours for the asking. For a detailed description of this process, how it works and the economic factors of cost and production, write us on your company letterhead.

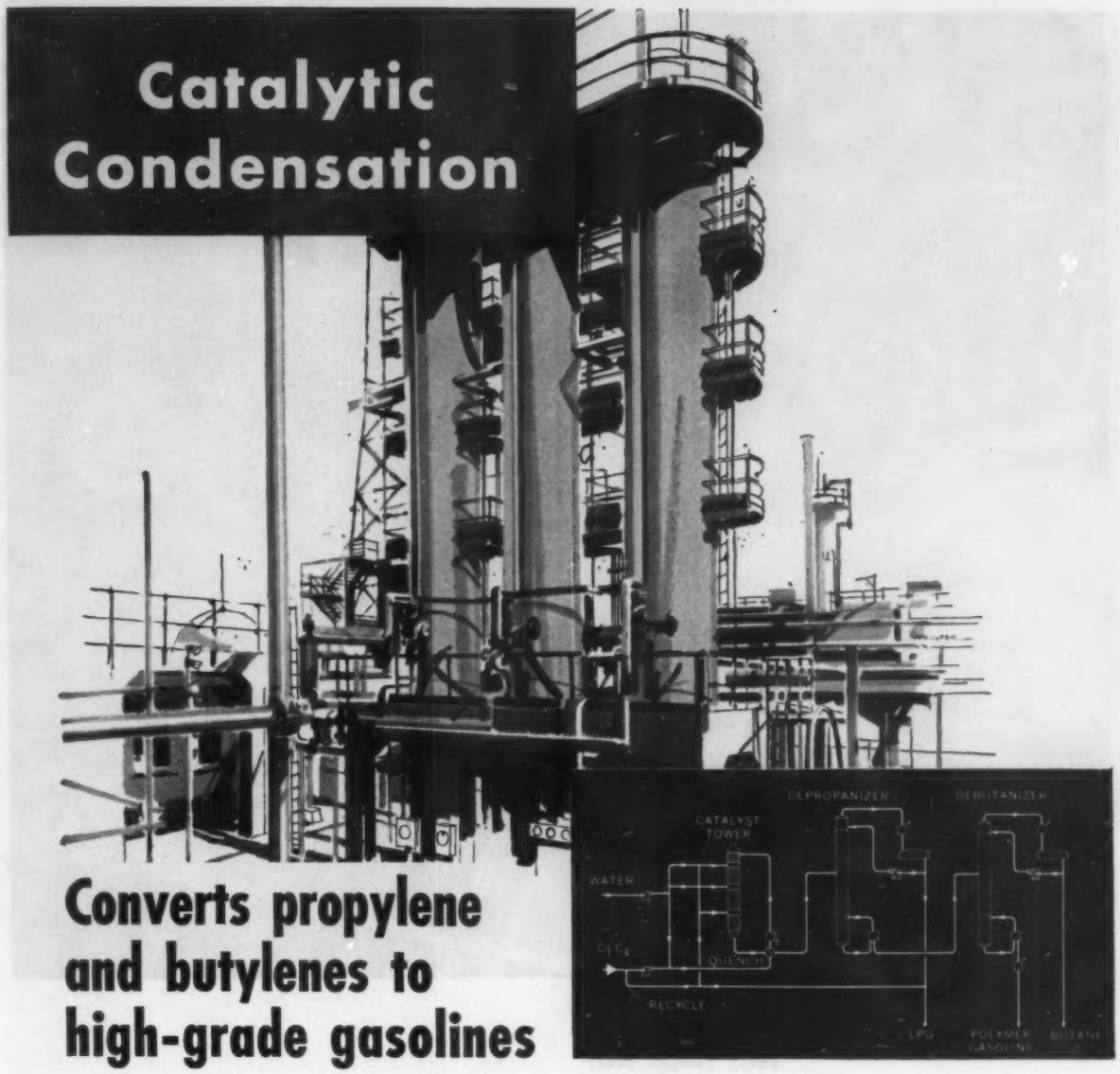
UOP®

UNIVERSAL OIL PRODUCTS COMPANY

30 ALGONQUIN ROAD, DES PLAINES, ILLINOIS, U.S.A.

More Than Forty Years Of Leadership In Petroleum Refining Technology

Catalytic Condensation



Converts propylene and butylenes to high-grade gasolines

This is another UOP process designed to help the refiner realize his greatest potential. Catalytic Condensation converts the propylene and butylene portions of refinery gas into high grade motor gasolines, by contact with UOP Solid Phosphoric Acid catalyst. Polymerization may be controlled to yield products which, on hydrogenation, produce saturated gasolines of high octane number.

Catalytic Condensation also offers an efficient means for producing specialty polymers of light olefins, for which there is a rapidly growing market for chemical use. For example, propylene can be polymerized to products rich in C_6, C_9, or C_{12} olefins, which are useful as raw materials for producing detergents and alcohols. The process may also be used to react ethylene and propylene with benzene to form, respectively, ethylbenzene for the production of styrene, and cumene for use in manufacturing acetone and phenol.

This is but one of many refining and petrochemical processes available from UOP. Write for process brochure and detailed information.

UNIVERSAL OIL PRODUCTS COMPANY

30 Algonquin Road, Des Plaines, Illinois, U.S.A.

More Than Forty Years Of Leadership In Petroleum Refining Technology

For more data on advertised products, use Readers' Service Cards, last page.

A step up in safety...

BLAW-KNOX Electroforged® Steel Grating and Treads

Indoors or outdoors the safe way to build a walkway is with Blaw-Knox Electroforged steel grating. Nonslip twisted crossbar provides the safest possible surface. Self-cleaning, steel grating does not collect dirt or grease . . . provides maximum open area for light and ventilation.

Designed for flexibility, one-piece construction installs easily around beams, piping, machinery or other installations. Needs no maintenance . . . nothing to wear. All surfaces accessible for easy painting.

For more detailed information about how to order Blaw-Knox Electroforged steel grating and treads for your needs, send for your copy of Blaw-Knox Bulletin number 2527-R.

BLAW-KNOX

BLAW-KNOX COMPANY
Equipment Division
Dept. D, Pittsburgh 38, Pennsylvania

Insulation in a single layer! Caposite was developed by The Cape Asbestos Company to avoid the 'two-layer compromise' Caposite does it in one—saving considerably on installation time and costs. Caposite, the amosite asbestos insulation, is designed to withstand temperatures up to 1000° F. without loss of efficiency.

LOW JOINT LOSS

The fibrous edges of Caposite knit together at the joints giving a good heat seal and making staggered joints unnecessary.

EASY TO HANDLE

Its inherent strength makes it possible to handle Caposite in large sections for example at 2" thick for 30" n.p.s.—with very little damage and a further saving in installation costs.

One layer— Less work

CAPOSITE single-layer insulation

CAPE

THE CAPE ASBESTOS COMPANY LIMITED 114 & 116 Park Street, London W. 1, Grosvenor 6022
Cables: Incorrupt London

Enquiries in Canada to: Cape Asbestos (Canada) Limited, 200 Bloor Street East, Toronto, Ontario.
U.S.A.: North American Asbestos Corporation, Board of Trade Building, Chicago 4, Illinois.

TA 2343

USCOLITE PLASTIC PIPE

CONFUSED ABOUT PLASTIC PIPE?

(MOST EVERYONE IS)

Here's your guide:

U. S. Uscolite® CP acrylonitrile-butadiene-styrene copolymer (ABS-I) pipe is best where maximum resistance to impact is demanded. It will safely handle most chemicals of industrial importance at working temperatures up to 170°F. This is the major plastic pipe used by chemical processing industries.

U. S. Uscolite RV polyvinyl chloride (PVC-I) pipe is best for extremely active oxidizing agents such as strong sulphuric, nitric and chromic acids. This unplasticized, unmodified Type I PVC has high impact strength and handles temperatures up to 140°F, far in excess of normal requirements.

Uscolite HT (ABS-II) pipe is a new addition to the resin-rubber compounds. HT stands for exceptionally High Tensile qualities, plus much better retention of physical properties at High Temperatures.

These types of Uscolite Pipe cover all requirements, not only because they are virtually immune to internal and external corrosion, but they are non-contaminating, odorless, impart no taste or discoloration. Because of these qualities they are approved by the National Sanitation Foundation for carrying drinking water. The use of Uscolite results in a saving of appreciable dollars in installation costs and reduction in man-hours. The skills to install metal pipe are not required to install Uscolite. Assembly can be accomplished in half the time. *Not one foot of Uscolite Pipe has ever failed in service when used in accordance with our recommendations.*

A fourth pipe, *UscoFlow HT (ABS-II)* is a black utility pipe, especially suitable where low first costs are a factor. It's a blend of styrene-base resin and synthetic rubber for good impact resistance and high tensile strength. UscoFlow is the ideal answer to builders and large developers who are seeking long-lived, maintenance-free pipe for plumbing.

We invite detailed inquiries or call your "U. S." plastics distributor. He has the *largest* line of plastic pipe and fittings, plus an experienced background to settle any and all questions about which pipe to use.

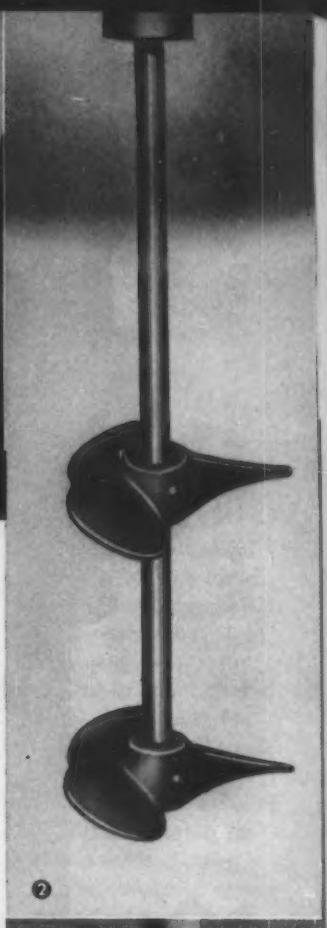
Mechanical Goods Division

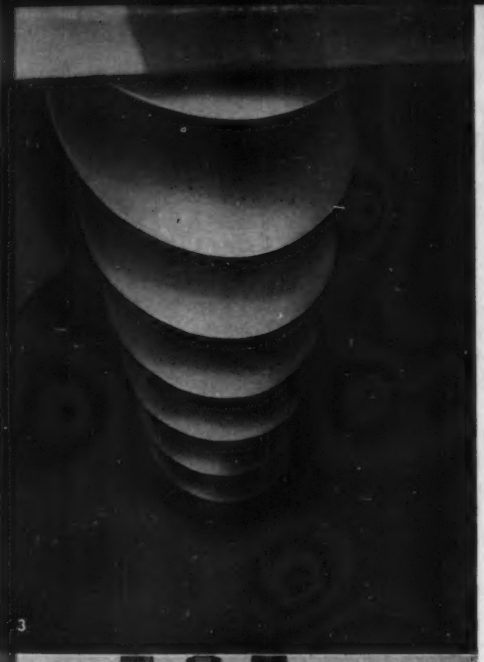
United States Rubber

WORLD'S LARGEST MANUFACTURER OF INDUSTRIAL RUBBER PRODUCTS

Rockefeller Center, New York 20, N.Y. In Canada: Dominion Rubber Company, Ltd.

Improved Processing through Engineered Agitation



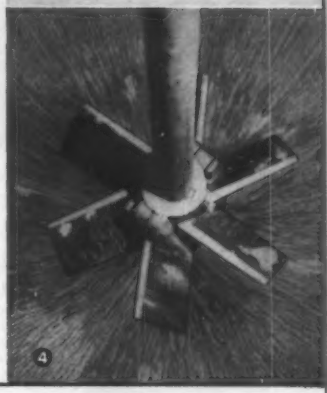


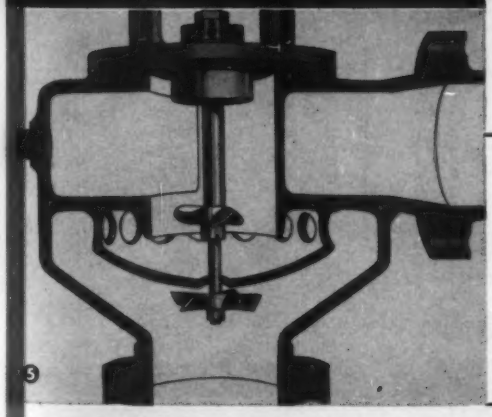
IMPELLER SELECTION . . . THE INSIDE STORY OF GOOD MIXING

THE DESIGN AND PERFORMANCE OF THE IMPELLERS are major factors in the success of process mixers. Determining the right impeller requires a thorough knowledge of below-the-surface action of different impellers in a wide variety of fluids of different density and temperatures.

THROUGH CONTINUOUS RESEARCH AND EXPERIENCE . . . gained in thousands of pilot runs and working installations . . . NETTCO has acquired the impeller know-how so important to efficient mixing. And this below-the-surface know-how can cut your processing costs by minimizing horsepower requirements!

YOUR NETTCO REPRESENTATIVE CAN HELP YOU make your process more efficient . . . more profitable. See Chemical Engineering Catalog or Refinery Catalog for his address or write for Bulletin 581, New England Tank and Tower Co., 81 Tileston St., Everett 49, Mass.



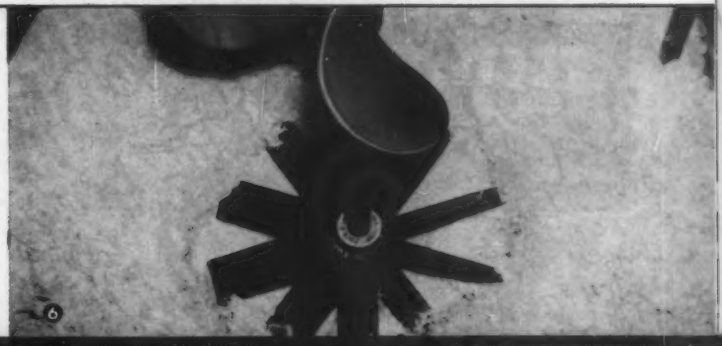


NETTCO

ENGINEERED AGITATION SPECIALISTS

EVERETT 49, MASSACHUSETTS

1. Vertical finger and breaker stirrers used in the dispersion of high viscosity materials.
2. Medium speed propeller recommended for medium size batch mixing of low viscosity material.
3. Corrosion-proof, plastic covered flight impeller which automatically provides variable agitation for variable tank volumes.
4. Split turbine stirrer designed for pressure tanks where minimum tank opening size is necessary.
5. Flomix impellers for continuous pipe line mixing of solids and medium to low viscosity material.
6. Standard turbine and propeller combination provides vigorous agitation for solid suspension, heat transfer and blending.



corrosion coupons prove...

KONTOL

REDUCED CORROSION IN PLATFORMER OVERHEAD VAPOR RECOVERY SYSTEM FROM 11.74 TO .14 MPY*

In an eastern refinery severe corrosion was encountered in the prefractionator overhead vapor recovery system in one of its platformers. This unit was charged with about 1500 b/d of naphtha—300 bbls. overhead, 1200 bbls. removed as side cut and used as charge to reactors.

After the first month of operation, overhead vapor line and reflux line of silica tower and clay tower had to be replaced. Reflux pump and reactor charge pump had to be relined and new impellers installed. Severe corrosion was noted in condenser bundles. Throttling valves were renewed several times.

KONTOL was then injected into the overhead vapor line from the prefractionator. Corrosion test coupons installed in a by-pass on the reflux line revealed the following results:

Date Installed	Date Removed	M. P. Y.*	Kontol
12/18	12/26	11.74	No
12/26	1/2	7.96	Yes
1/19	2/2	.41	Yes
2/2	2/23	.17	Yes
2/23	4/28	.12	Yes
5/13	10/12	.14	Yes

*Mils penetration per year

KR-50-2

For help in controlling *your* corrosion problem, ask the Man in the Tretolite Car, or *write for your copy of the latest KONTOL brochure*, complete with performance data, case histories, etc. No obligation.

PETROLITE CORPORATION

TRETOLITE COMPANY DIVISIONS

369 Marshall Avenue, Saint Louis 19, Missouri
5515 Telegraph Road, Los Angeles 22, California

CANADA: Petrolite Corporation of Canada, Limited, 309 Alexandra Bldg., Edmonton, Alberta

ENGLAND: Petrolite Limited, Heathcoat House, 20 Savile Row, London W. 1

VENEZUELA: South American Petrolite Corporation, Hotel Avila, Caracas

REPRESENTATIVES

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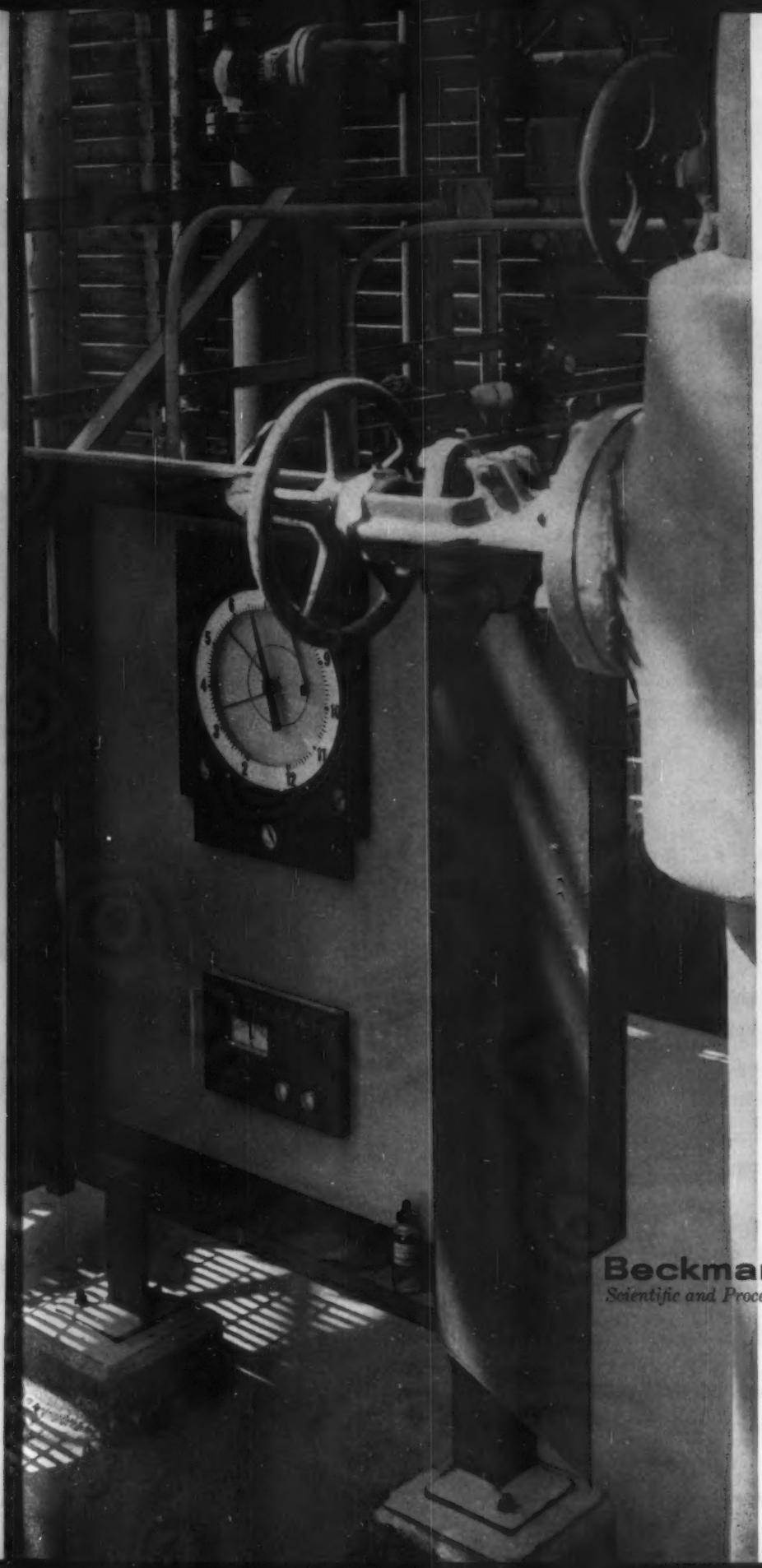
ITALY: NYMCO S.p.A. 9, Lungotevere A. da Brescia, Rome
JAPAN: Maruwa Bussan KK, No. 3, 2-Chome, Kyobashi, Chuo-Ku, Tokyo
KUWAIT: F. N. Dahdah, Box 1713, Al Kuwait
MEXICO: R. E. Power, Sierra de Mijes, No. 125, Mexico, D. F.
NETHERLANDS: F. E. C. Jenkins, Hoefbladlaan 134, The Hague
PERU: Oilfield Import, S. A., Apartado 71, Talara
TRINIDAD: Neal and Massy, Ltd., P.O. Box 544, Port of Spain



4 minutes' attention for 24-hour operation

Just 4 minutes a day and a Beckman Model W Industrial pH meter are all it takes for a technician to prevent equipment corrosion by continuous pH control of cooling tower water at Collier Carbon and Chemical Corporation, Brea, California.

For over two years, this small Beckman pH amplifier has continuously maintained cooling water at a pH of 6, correcting all variations automatically in about 15 seconds. And, except for the few minutes attention required every morning for routine meter standardization, it has provided maintenance-free operation.

Beckman pH equipment can also give *you* dependability with minimum attention. The reason: printed circuitry, plug-in assemblies, and ruggedized industrial electrodes.

Beckman makes and sells more industrial pH equipment than any other manufacturer in the world. Equipment and services are provided by leading recorder companies. For a list of these companies and instrument specifications, write for Data File 25-10-06.

Beckman
Scientific and Process Instruments Division
Beckman Instruments, Inc.
2500 Fullerton Road, Fullerton, California

It's a Fact: More than 500,000,000 hours have been logged by Beckman industrial pH meters...measuring and controlling pH in industrial processes.

300

ANNUAL EDITION

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for REFINING • NATURAL GASOLINE • PETROCHEMICALS

In a hurry? Eight out of nine planners, buyers and specifiers turn to REFINERY CATALOG in preference to individual suppliers' literature when figuring a job. They know that REFINERY CATALOG is always current, that it's indexed and cross-indexed for quick, accurate reference. That's why more than 300 manufacturers and service companies put their complete or condensed catalogs in REFINERY CATALOG. Here they are "on call" 24 hours a day.

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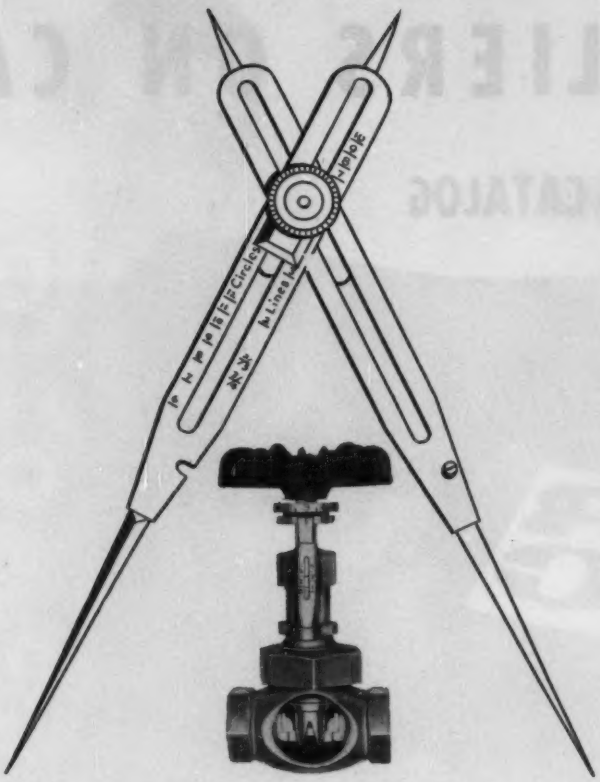


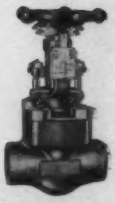
PROPORTIONER

controls flow to save for you

The V-port disc in all Hancock "Flocontrol" Valves insures proportional flow throughout the entire lift of the stem. They are valves that help you achieve uniform product quality through closer control, save steam and fuel on process work, and cut maintenance costs.

"3 in 1" valve design combines variable orifice with shut-off and micrometer dial and pointer. The valve opening can be set within 1/10 turn of the handwheel —you can duplicate all settings easily, instantly. No shut-off valve required—flow is in a straight line, with separate shut-off seating surface located away from the V-ports.

Hancock "Flocontrol" Valves are available in Bronze and Steel to meet the most demanding services. Ask your industrial supply distributor for details.



Hancock "Flocontrol" valves assure positive pinpoint control—eliminate all guesswork.

MAXWELL MANNING & MOORE INC. TRADE MARK

HI-50

HANCOCK "FLOCONTROL" VALVES

A product of

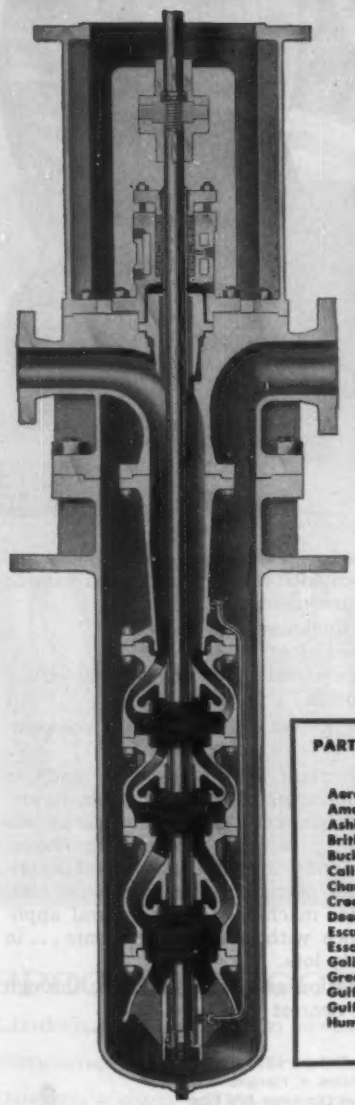
MANNING, MAXWELL & MOORE, INC.

Consolidated Ashcroft Hancock Division • Watertown, Massachusetts

In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario

For more data on advertised products, use Readers' Service Cards, last page.

NEW! *Bingham* VCP VERTICAL PUMP FOR LOW NPSH



ALL WORKING PARTS ACCESSIBLE WITH BOTTOM DISMANTLING

Besides bottom dismantling, which in itself greatly reduces maintenance time when attention is required, this new Bingham pump incorporates advanced features which minimize maintenance, reducing need for periodic inspection.

For example, all intermediate bearings (supplied of appropriate material for different pumpages) are forced-lubricated by pumpage. Bottom bearing is lubricated, even if pump runs dry for short periods. This *dependable* lubrication greatly prolongs life of bearings, which in conventional pumps are frequently the cause of maintenance shutdowns.

All working parts of pump easily accessible with bottom dismantling. One man can service after lifting pump from well.

Various operators estimate that time required to reach working parts has been reduced as much as 50%.

Wherever installed, the Bingham VCP Pump has given trouble-free service—plus unsurpassed smooth operation with no vibration. Available for any capacity or head. Write your nearest Bingham office for additional information.

By dismantling from bottom, repair or replacement of any part can be made in less time than with conventional pumps (where dismantling begins from top, necessitating removal of driver and head before pump unit is accessible).

PARTIAL LIST OF MAJOR OIL COMPANIES WITH BINGHAM "VCP" PUMPS IN OPERATION OR ON ORDER:

Aerojet General Corporation
American Cyanamid Company
Ashland Oil & Refining Company
British American Oil Co., Ltd.
Buckeye Pipe Line Company
California Oil Company
Champlin Refining Company
Creole Petroleum Company
Deere & Company
Escambia Bay Chemical Co.
Esso-Standard Oil of N. J.
Golfad Oil & Gas Company
Great Lakes Pipeline Company
Gulf Oil Corporation
Gulf States Utilities
Humble Oil Company
Imperial Oil Company, Ltd.
Interstate Oil Company
Kanab Pipe Line Company
Lakehead Pipeline Company
National Coop. Refinery
Pacific Gas & Electric Co.
Pacific Petroleum, Ltd.
Phillips Petroleum Company
Shell Oil Company
Sinclair Oil & Refining Co.
Skelly Oil Company
Socony-Mobil Oil Company
Standard Oil Co. of Texas
Sun Oil Company
Union Carbide Chemicals Co.
United Fuel Gas Company
Warren Petroleum Company

Bingham SINCE 1921

DOUBLE VOLUTE PUMPS RADIAL BALANCE

BINGHAM PUMP COMPANY

General Offices: 2800 N. W. Front Avenue, Portland 10, Oregon

Factories: Portland, Ore. • Vancouver, B. C., Canada

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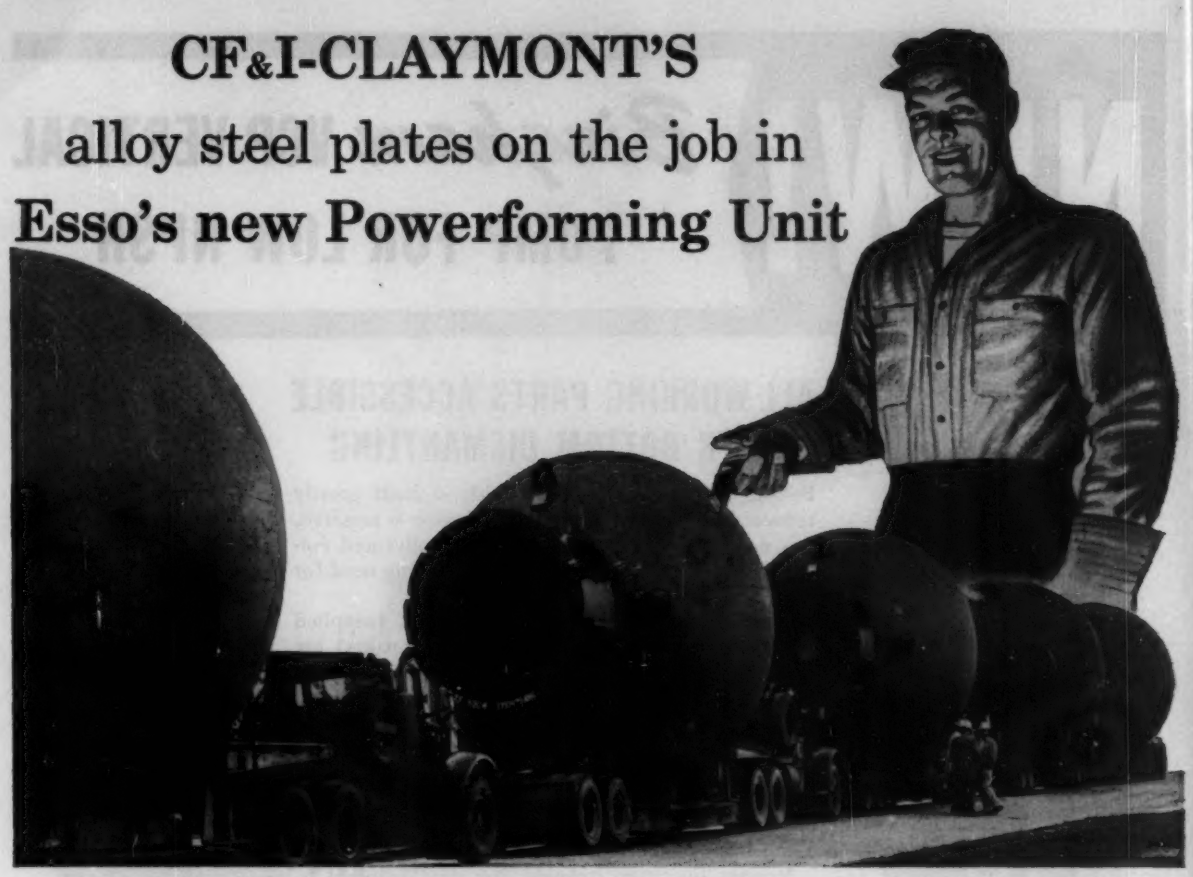
CF&I-CLAYMONT'S
alloy steel plates on the job in
Esso's new Powerforming Unit



The job: Produce five spherical reactors—Catalytic Reforming Units—to convert low octane gasolines to higher octane motor fuels.

The job site: Esso Standard Oil Company's new Powerforming Unit at Baton Rouge, Louisiana.

The job-team: Esso Research and Engineering Company prepared the basic design. Bechtel Corporation, San Francisco, developed the basic requirements and designed the various details. Wyatt Metal & Boiler Works, Inc., produced the shop drawings and fabricated the units in their Houston shops.

CF&I's Claymont, Delaware plant produced the alloy steel plates . . . for the shells and for manheads and nozzle connections.

The specifications: The CF&I-Claymont Alloy Steel Plates were manufactured to ASTM Specifications for Carbon-Molybdenum and Chrome-Molybdenum Steel . . . designed for high pressure and high temperature applications, with increased tensile and creep strength provided in accordance with varying safety factor requirements.

Minimum plate thickness—1⅞ inches.
I.D. of reactors—17 feet 1½ inches.
Net weight of each shell, without internal insulation—95,000 pounds.

The result: Another job well done through co-operative effort.

The CF&I-Claymont plant is equipped and ready to work with *you* by producing plate for any job, to any specification . . . in carbon, alloy or stainless-clad steels . . . in the dimensions, gage and shape of your choice. What's more, Claymont's completely-equipped Fabrications Shop turns out partially or full-fabricated steel plate components (for machinery or structural applications) in accordance with user requirements . . . in small or large-quantity lots.

Get complete information and prompt service through the CF&I sales office nearest you.

CF&I-CLAYMONT PRODUCTS: Carbon Steel Plates • Alloy Steel Plates • Stainless-Clad Plates • CF&I Lectro-Clad Nickel Plated Steel Plates • Clay-Loy High® Strength Low Alloy Steel Plates • Flanged and Dished Heads • Manhole Fittings and Covers • Fabricated Steel Plate Products • Large Diameter API Pipe

Claymont Steel Products

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In the East: **WICKWIRE SPENCER STEEL DIVISION**—Atlanta · Boston · Buffalo · Chicago · Detroit · New Orleans · New York · Philadelphia

CF&I OFFICE IN CANADA: Montreal **CANADIAN REPRESENTATIVES AT:** Calgary · Edmonton · Vancouver · Winnipeg

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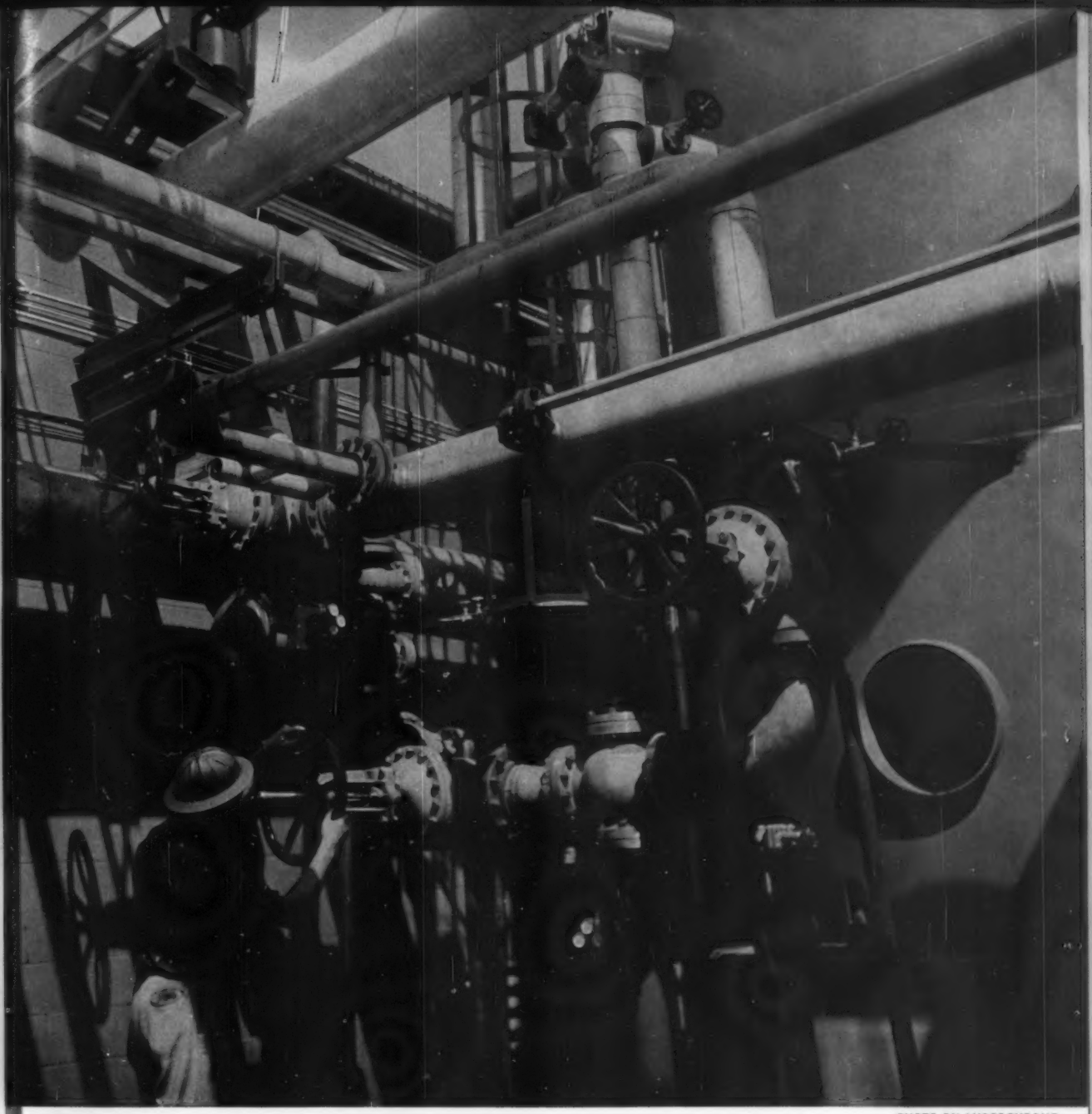


PHOTO ON ANSCOCHROME

SPECIAL PROCESS... General Aniline & Film Corporation's new plant at Linden, N. J., went on stream last year. Built by Scientific Design Co., Inc., it produces ethylene oxide by direct air oxidation of ethylene, Scientific Design's own efficient and economical process. The Aloyco Stainless Steel Valves here (red hand wheels) were selected for their design features and long life expectancy. On your next stainless steel valve job, why don't you talk first to the one company which specializes in high alloy valves exclusively. For further details about Aloyco Valves, write us at 1301 West Elizabeth Avenue, Linden, New Jersey. 9.5

ALLOY STEEL PRODUCTS COMPANY

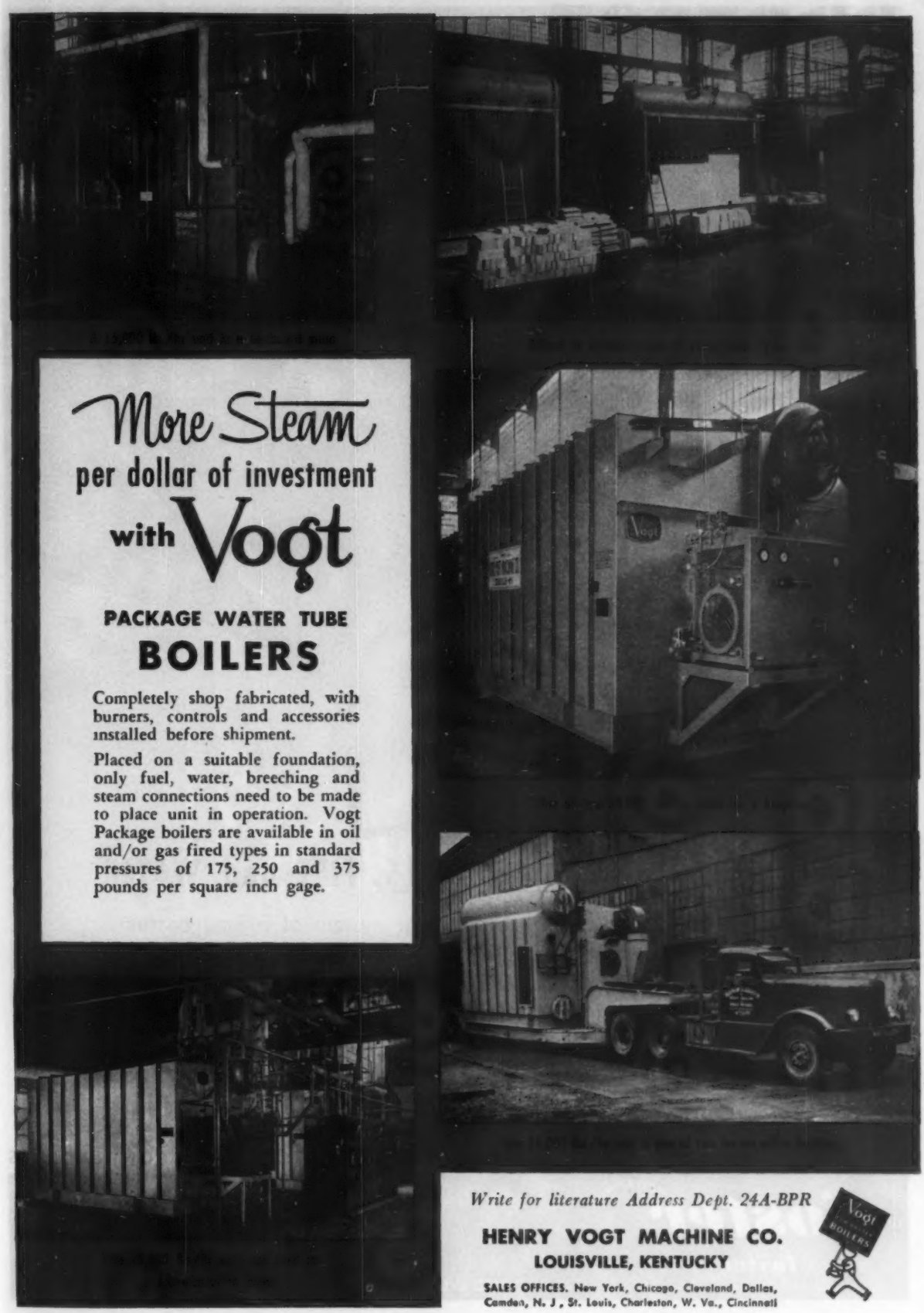
Boston · New York · Wilmington · Atlanta · Buffalo · Pittsburgh · Chicago · St. Louis · San Francisco · Los Angeles

Photographed in the Trianon Room, Sheraton East Hotel, New York, N. Y.

The oilman: big hit in this year's fashion show.

Your wife might be surprised to know just how important your industry is to American women. You and oil helped develop oil-based synthetic fabrics dainty as lace, tough as overalls. Oil-based synthetic dyes that challenge the rainbow. Oil-based treatments that put new life into natural fabrics. The next time you hear somebody start to talk against the oil industry, tell him you're an oilman—and proud of it. And tell him why.

SHELL OIL COMPANY



More Steam per dollar of investment with Vogt

PACKAGE WATER TUBE BOILERS

Completely shop fabricated, with burners, controls and accessories installed before shipment.

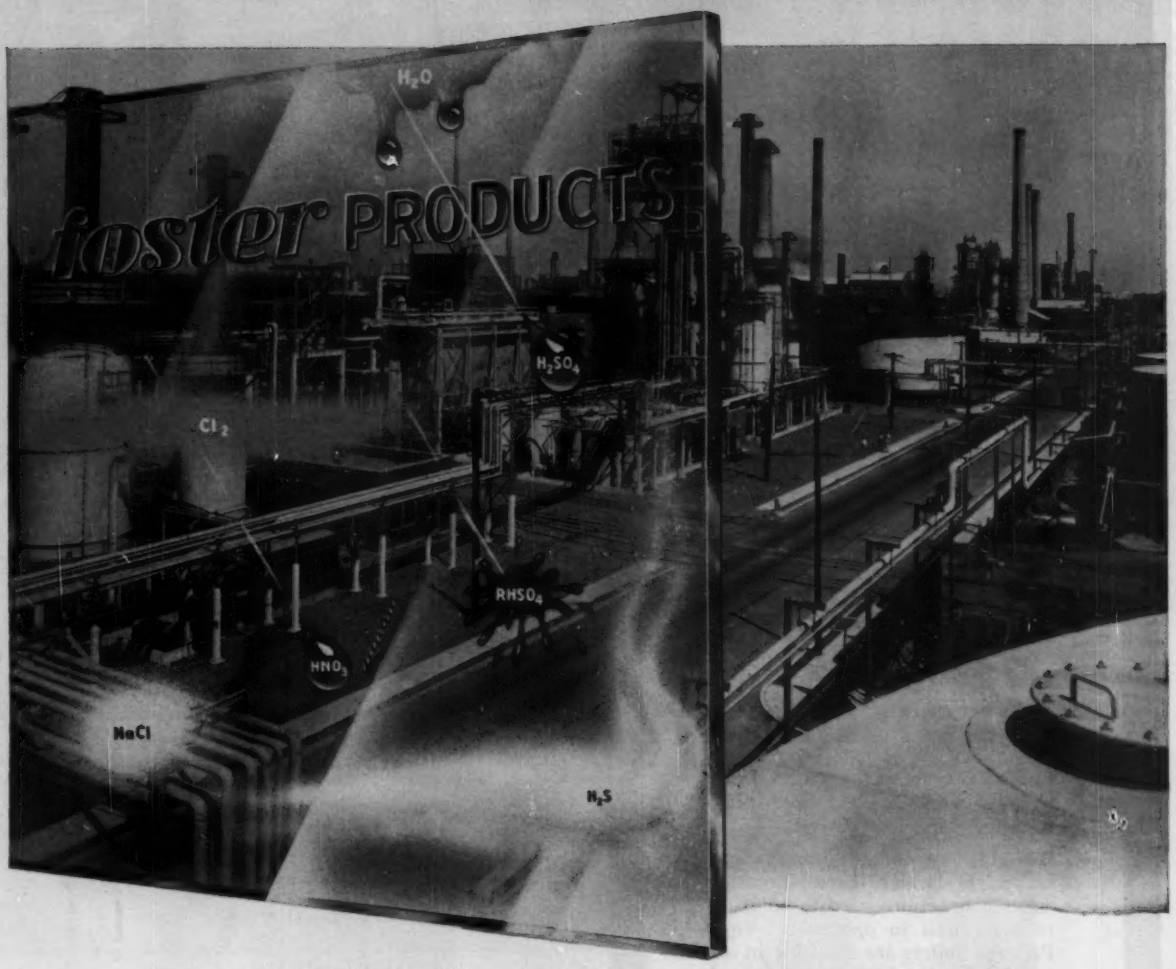
Placed on a suitable foundation, only fuel, water, breeching and steam connections need to be made to place unit in operation. Vogt Package boilers are available in oil and/or gas fired types in standard pressures of 175, 250 and 375 pounds per square inch gage.

Write for literature Address Dept. 24A-BPR

HENRY VOGT MACHINE CO.
LOUISVILLE, KENTUCKY

SALES OFFICES. New York, Chicago, Cleveland, Dallas, Camden, N. J., St. Louis, Charleston, W. Va., Cincinnati

PROTECT *thermal insulation*



RESISTS CHEMICALS, FIRE and WATER

There's a specialized Foster system of rugged coatings, sealers, and adhesives developed to meet your toughest problem of thermal-insulation protection. Insure your insulation investment throughout your plant—see your Foster Sales Engineer, or outline your conditions in a card or letter.

INSULATION & PROTECTION

IT TAKES BOTH TO DO THE JOB

SOLD BY AMERICA'S LEADING INSULATION DISTRIBUTORS AND CONTRACTORS

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BENJAMIN foster CO.
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4635 W. GIRARD AVE. • PHILA. 31, PA.

standard products for thermal insulation protection

ENGINEERED APPLICATION of pumping systems means getting the right pump to do your liquid-handling job most efficiently.

Meaning? You must choose from a wide variety of pump designs, sizes, materials, performance characteristics. You need to know what special pumps handle acids, paper stocks, corrosive alkalies, salt water, slurries.

Impossible? Not for an expert. And Goulds provides the expert every time you need a pump. Goulds' application engineers specialize in every pump field to help you select *just* the pumping system you need.

The next time you're faced with a decision on what pump to buy, call in a Goulds man to look the problem over. He'll cut corners where he can, but make no sacrifices of quality or safety. And when he says, "This is it!" you can *depend* on it.

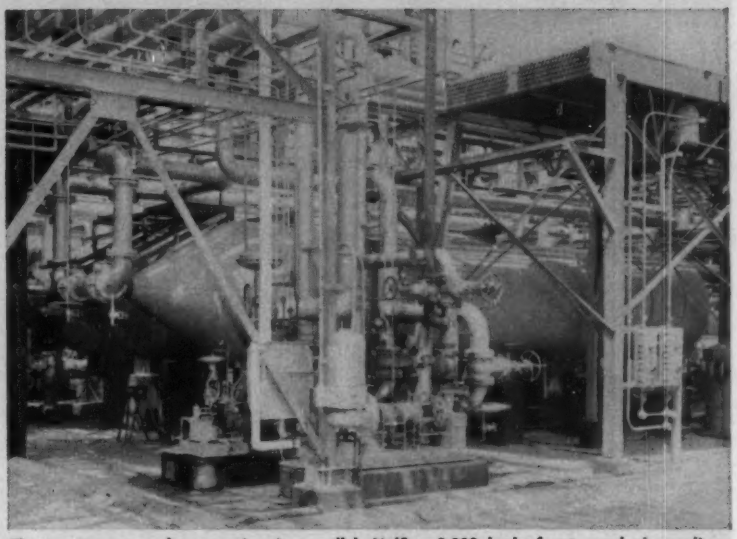
For help in solving *your* pumping problem, write to: Goulds Pumps Inc., Dept. PR-109 Seneca Falls, N. Y.

GOULDS GP PUMPS

For more data on advertised products, use Readers' Service Cards, last page.

Nalfining: Unique New Upgrading Method for Low-Cost Processing of Distillates

Contaminants Problem Solved without Major Investment; with Minimum Attention and Control Procedures



Three process vessels, operating in parallel, Nalfine 3,000 bpd of cat. cracked gasoline.

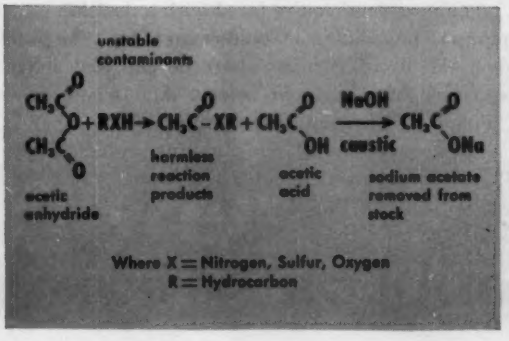
Improvement of color, stability and odor of distillates through Nalfining changes the entire economic aspect of treating processes. Instead of equipment installation costs ranging from $150 to $300 per barrel of throughput capacity, Nalfining installations run from 50¢ to 75¢ per barrel of capacity!

Processing costs with Nalfining offer almost as startling economies . . . First, because Nalfining makes possible a wide range of process variation without affecting upgrading results: testing, control and personnel training requirements are minimized . . . There are no disposal problems with Nalfining . . . And chemical costs range from 3 mils/barrel on low sulfur stocks to 3¢ to 5¢/bbl. on sour gasolines and oil stocks.

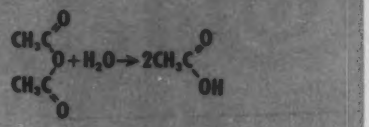
Simple Basic Process

Nalfining makes use of the interaction between acetic anhydride and unstable, reactive components in light fractions to produce harmless, unreactive, odorless compounds which do not precipitate or cause product losses.

While the complex chemical nature of components in most stocks make definite identification of reactions difficult, the following reaction offers a possible explanation of how the process functions:



Nalfining is also effective with fuels containing water haze following distillation. Apparently this is possible because hydrolysis of acetic anhydride proceeds at a slower rate than the primary reaction.



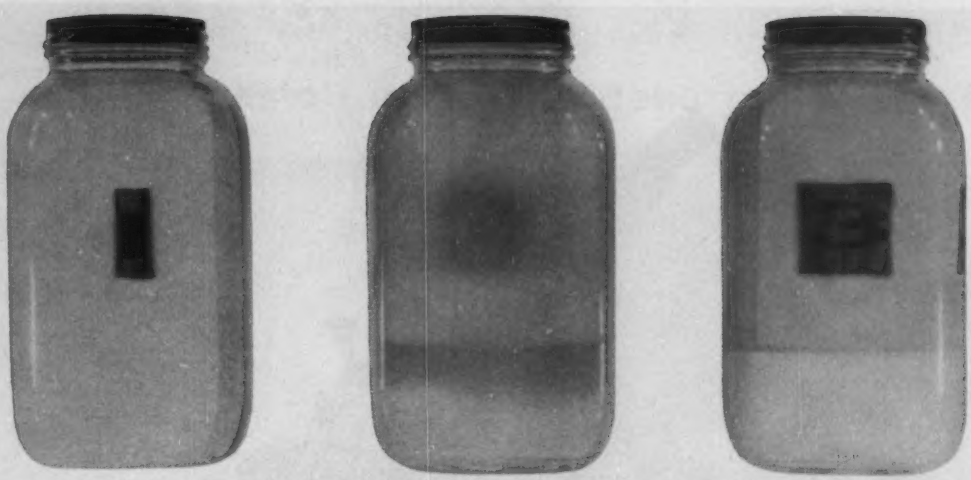
Equipment Costs Low

Installing the Nalfining process is much less costly than that for most refining processes because the required equipment is very simple, and expensive instrumentation and control costs are eliminated. Successful Nalfining installations have been set up by utilizing process vessels or tanks formerly used for caustic or acid treating operations. Aluminum storage tanks, pumps and lines to handle acetic anhydride are normally the only new equipment necessary.

Few, Simple Process Controls

Day-to-day control of Nalfining consists of simple tests to check reagent concentrations, completeness of reactions, and treated product quality. Other than these few tests, which can be made with equipment readily available in any control laboratory, and minor adjustments for operation, there are *no* other personnel needed for Nalfining . . . With reliable pumps and equipment, process upsets *do not* occur.

For more data on advertised products, use Readers' Service Cards, last page.



Jar at left (1) is raw fuel oil. Center jar (Numeral 2 obscured) is same oil with caustic added. Note haze in oil and "rag" of impurities extending from oil-caustic interface into caustic. Jar at right (3) was treated with both acetic anhydride and caustic. Stock is clear, there is no "rag" or residue at oil-caustic interface, and stabilized product will stay clear, free of objectionable odors through storage, shipment and trouble-free use.

Nalco Service Provided

All Nalfining units are provided with the regular services of Nalco Technical Representatives, who conduct tests and take samples to provide detailed information on process effectiveness, unit performance and quality of finished product. Regular reports are made to refinery personnel.

Nalfining a Wide Range of Products

Experience to date with Nalfining proves successful, low-cost upgrading of heating oils, solvents, jet fuels, gasolines, kerosenes and other distillate stocks. Throughput volumes today range from laboratory pilot plant operations to 20,000 bpd processing of light cycle oil. Nalfining itself is capable of volume of throughput equal to any desired rate.

Thorough Products "Cleanup"

Nalfining does a thorough job of deactivating distillate contaminants. Mercaptans are converted to unreactive, odorless chemicals. Unstable nitrogen, sulfur and oxygen-containing impurities are stabilized to harmless, oil-soluble reaction products.

Nalfined products have no reactive tendencies which would promote color degradation or sludge formation. No emulsion-forming occurs with water or caustic; and the Nalfined effluent has negligible sodium content.

Complete Data Available

Nalfining is a patented process which is offered under license agreement to refiners. Complete data on the process are available upon request from Nalco and we will welcome the opportunity to discuss a license agreement with you.

National Aluminate Corporation is now

NALCO CHEMICAL COMPANY

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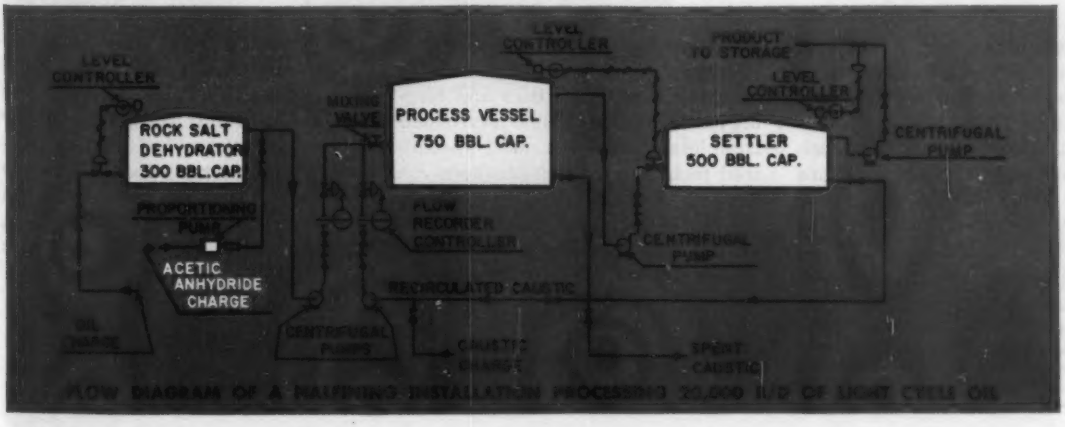
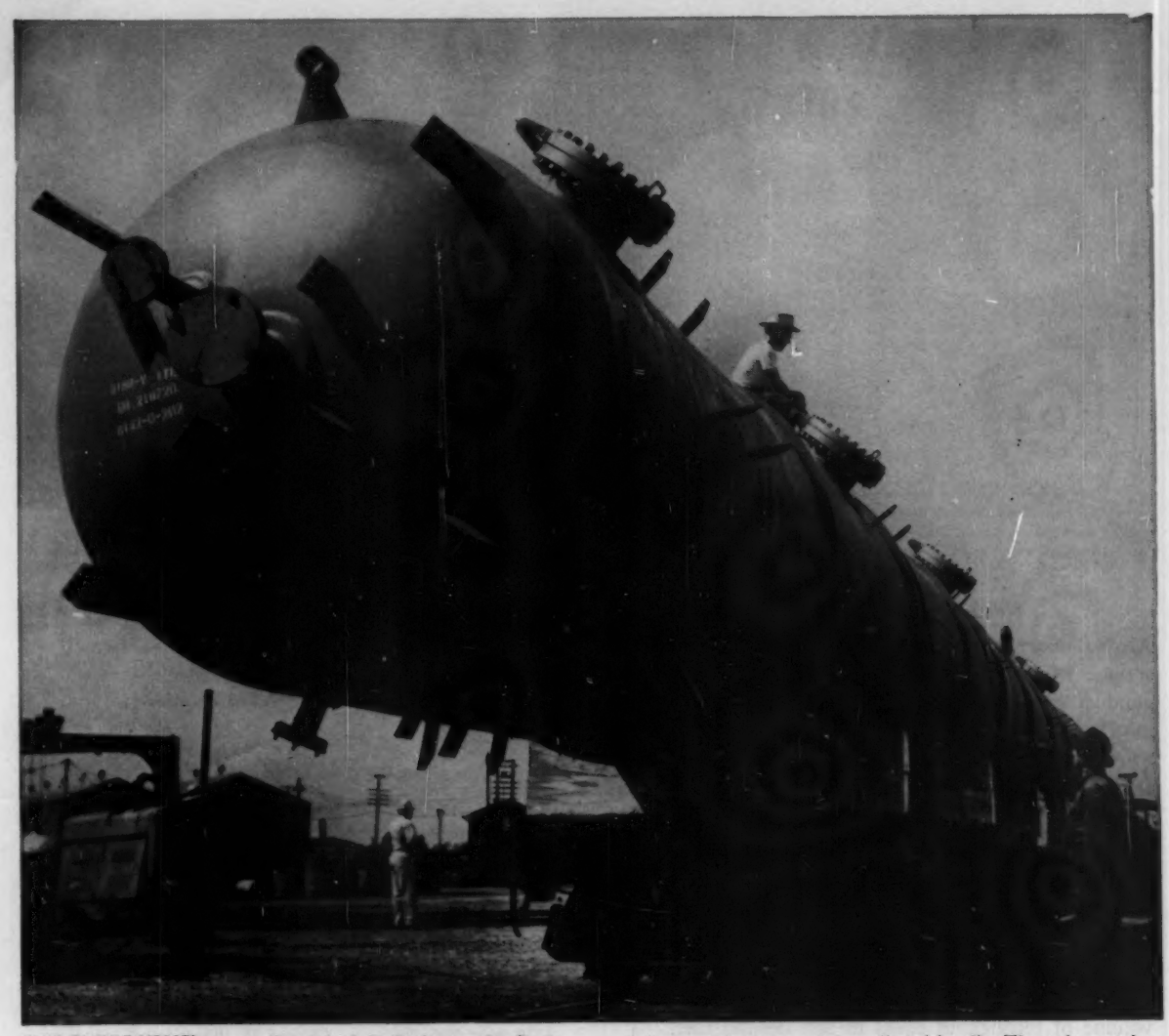
Nalco® ... *Serving Industry through Practical Applied Science*



FLOW DIAGRAM OF A NALFINING INSTALLATION PROCESSING 20,000 B/D OF LIGHT CYCLE OIL

For more data on advertised products, use Readers' Service Cards, last page.



THIS ENTIRE VESSEL was radiographed. Built for use by Socony Mobil Oil Company, Incorporated, it was stress relieved in thirds, and the two joints were stress relieved locally. The unit contains 30 uniflex trays of 96" diameter. Overall weight: 152,000 lbs.

Among the largest in use

...built by Newport News

This Debutanizer with a 110 feet 6 inches over-all length is typical of units that are readily built by Newport News . . .

In fact, Newport News can fabricate almost any type of pressure vessel or other heavy equipment used in the petroleum, chemical or other processing industries.

But at Newport News you'll find more than large productive capacity.

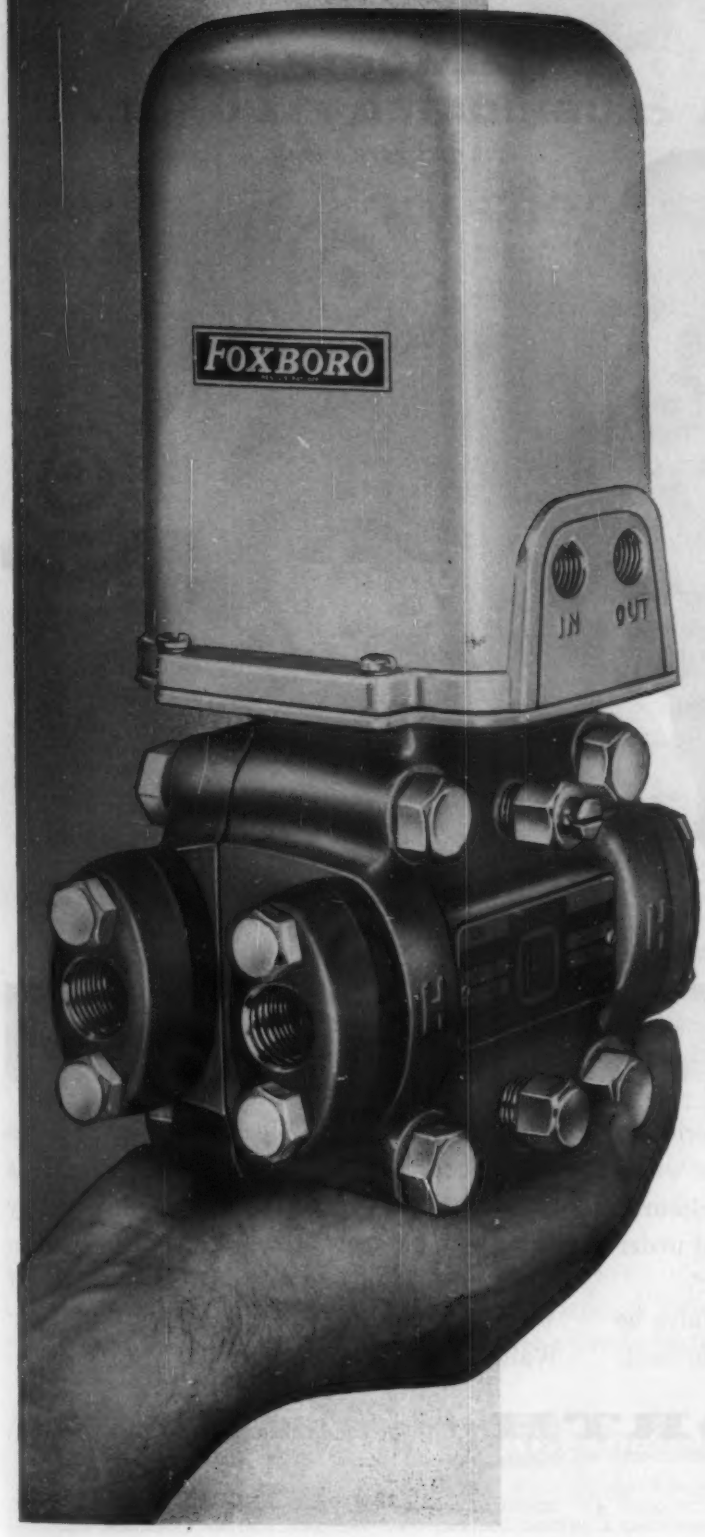
In vast fabricating shops, in huge machine shops, foundries and forging plants, Newport News craftsmen complete your order with specialized techniques. Plant methods . . . developed as a result of specializing for more than half a century . . . enable Newport News to provide money-saving answers to all sorts of heavy equipment problems.

Newport News craftsmen handle the job exactly as you want it done . . . for maximum results per dollar invested. So let us bid on your present or future projects. Learn how Newport News can help you. Send for our illustrated booklet entitled, "Facilities and Products"...it's yours for the asking.

Engineers — Desirable positions available at Newport News for Designers and Engineers in many categories. Address inquiries to Employment Manager.

Newport News Shipbuilding and Dry Dock Company
Newport News, Virginia

basic tool for process measurements . . .



FOXBORO d/p CELL* TRANSMITTERS

Positive overrange protection . . . no perceptible zero drift . . . high sustained accuracy, even under the most punishing operating conditions.

D/p Cell bodies are available in 316 s.s. or rustproofed carbon steel. Unique stainless steel twin-diaphragm capsule is specifically designed to provide positive overrange protection. Purged cover protects transmitter from weather, dust, and fumes.

You can install d/p Cells anywhere — in any position — simply and conveniently, and know they'll give unequaled accuracy and performance. Ask your Foxboro Field Engineer for complete details, or write for Bulletin 13-11A. **The Foxboro Company,**
7410 Neponset Avenue, Foxboro, Mass.

Foxboro d/p Cells for flow, liquid level, and other variables

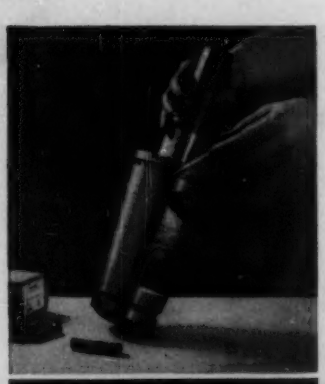
- for high-speed flow measurement and control
- for flow measurement as small as 0.03 gpm
- for flow under static pressures to 6000 psi
- for use where elevated or suppressed ranges are required
- for electronic flow control systems
- for liquid level
- for comparison of process and sample fluids
- for absolute pressure measurement

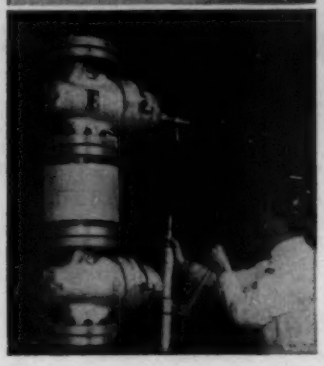
*Reg. U. S. Pat. Off.

Three fully adjustable ranges:
0-5 to 0-25 inches of water
0-20 to 0-250 inches of water
0-200 to 0-850 inches of water
Working pressures of 500, 1500, and 6000 psi

FOXBORO
REG. U.S. PAT. OFF.

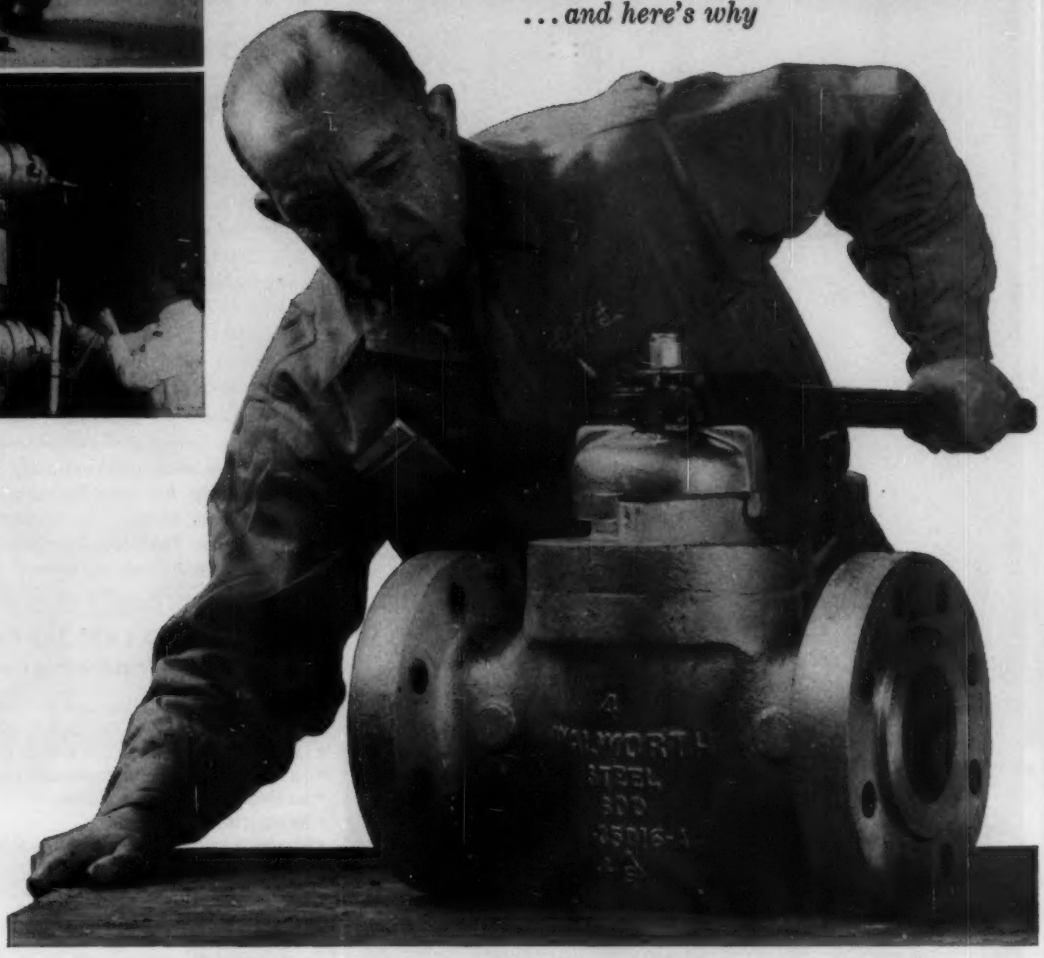
For more data on advertised products, use Readers' Service Cards, last page.





the **WALWORTH CUSTOMER**
wants a quick operating,
sure, tight valve. He chooses a

WALWORTH
LUBRICATED PLUG VALVE
. . . and here's why



When the Walworth Customer has to decide on a valve that will close fast and easily, he wants to know HOW fast . . . HOW easily. Tight closure? Of course. But can the valve be serviced under pressure? Yes. Still, he tries one himself.

In the Walworth Lubricated Plug Valve he finds 100% tight closure because it is lubricant-sealed against leakage. He finds it opens or closes with a quarter turn. Then, and only then, he's ready to buy. If that's the way you like to buy valves, we want you, too, for a Walworth Customer. For details on all types and ratings of Walworth Lubricated Plug Valves, ask your Walworth Distributor.

Or write **WALWORTH** *750 Third Avenue, New York 17, N. Y.*
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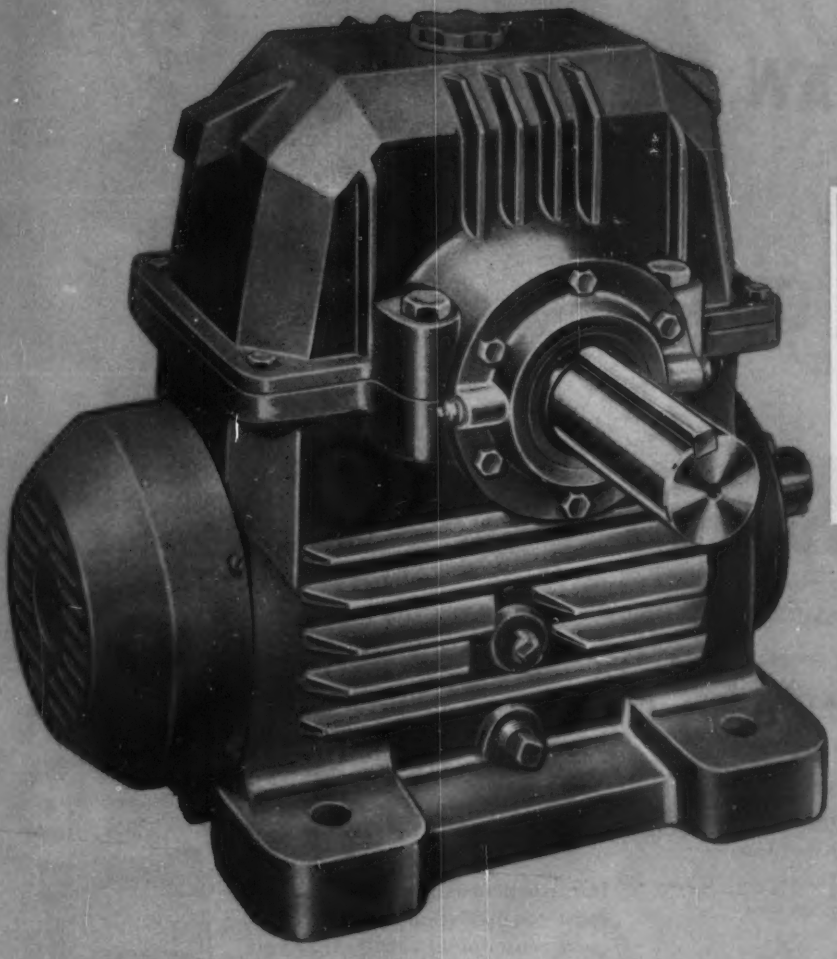
DELROYD
SPEED REDUCERS

DeLaval Announces All New Line of Single Reduction Speed Reducers



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fan cooled 5" through 12" center distance
★

Send for this new 32-page Bulletin 3805 today.

New Delroyd single reduction speed reducers are available in a wide range of sizes and horsepower ratings. These worm gear units include centrifugally cast gears and fan cooling, and carry *the new AGMA ratings.*

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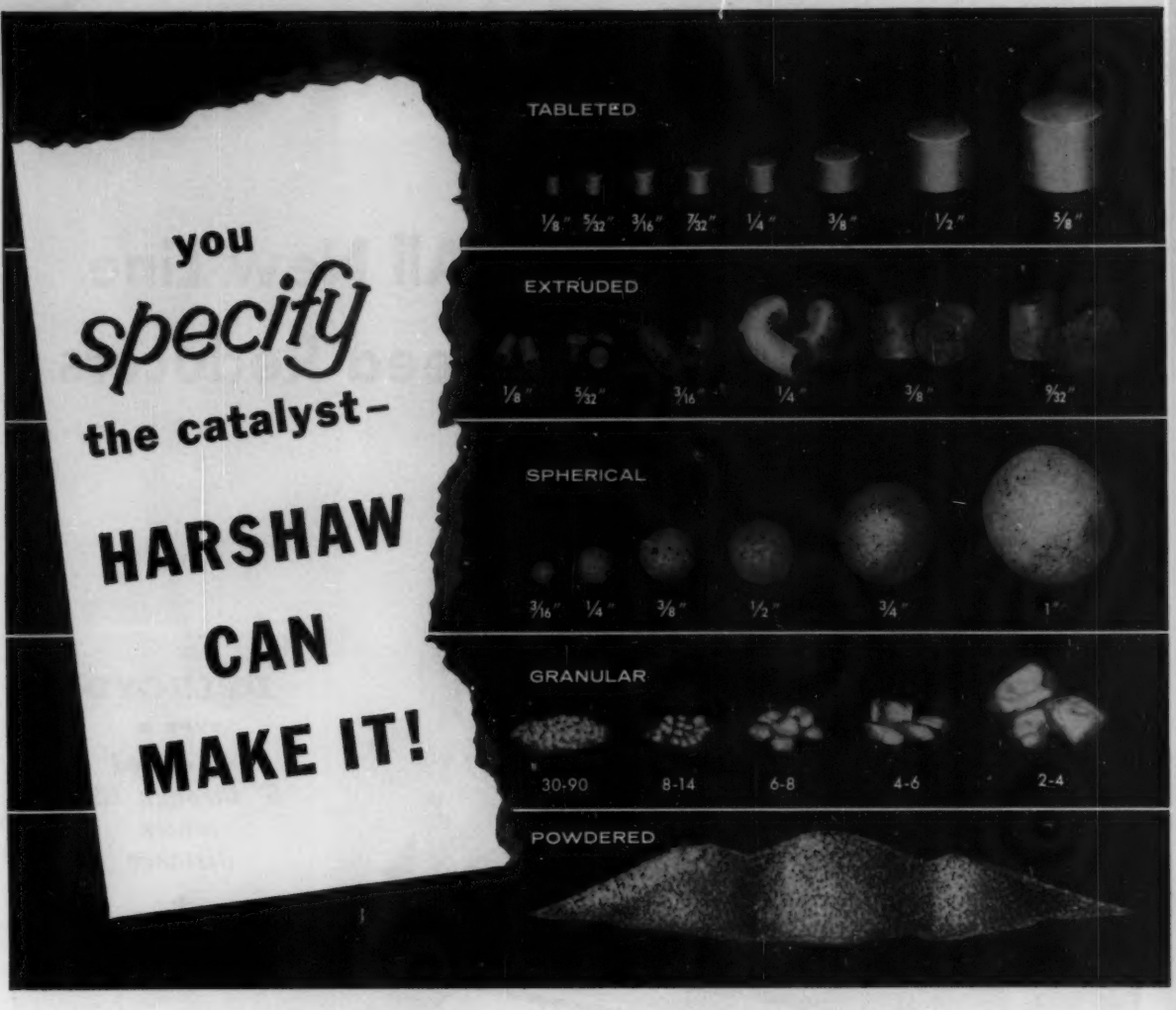

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Aluminum Nitrate		Cobalt Nitrate
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Our experienced technical staff will assist you in developing the best and most economical catalyst. If you have a catalytic process in the development or production stage, a discussion with us may prove beneficial.

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Petroleum and Petro-Chemical plants by JGC

As in the ancient pyramids, superior technical know-how and the finest in engineering performance are today still the inseparable factors that construct to endure. During the past 30 years the Japan Gasoline Company has built some of the best petroleum and petro-chemical plants in Japan, providing a highly diversified service in building... from the designing to the construction ...all in one favorable contract. An expert staff offers competent planning for every step of the way... with the assurance to meet the demands of the most exacting customer.

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Pyramids of Modern Times

HELPFUL WATER CONDITIONING DATA FROM BETZ

WATER TREATMENT FOR

■ The newer developments of treatment for compressor and engine jacket systems have made water-side problems a thing of the past

THROUGHOUT THE YEARS the problems connected with the removal of heat from engines and compressors have received considerable attention from engine manufacturers, plant operating personnel, and water treatment consultants.

Engines and compressors first were designed for use with low temperature water at low velocity. These designs resulted in a large temperature rise through the system which set up unequal stresses in the metal, causing serious failures. To overcome this problem and to increase the efficiency of the equipment, manufacturers' designs have been changed so that the modern engines now operate with a rapid flow of water at a relatively high temperature, and with a temperature rise of only 10 to 15 F throughout the system.

At one time, little if any attention was given to the cooling water. It was not uncommon to use water on a *once-through* basis, taken from a stream that was subject to marked variations in dissolved solids and more particularly in suspended solids. Well waters high in hardness often were used so that heavy scale formation was common. Soon it was learned that scale formation and deposit accumulation from suspended solids could not be tolerated.

In other cases, cooling of the engines was accomplished with an *open recirculating system* using a cooling tower or a spray pond for dissipation of the heat. This method of cooling was a step in the right direction and permitted better control of the problems of scale formation, corrosion and slime. However, water-side problems could not always be solved economically, even with this type system.

The *closed recirculating system*, as illustrated by the dotted lines in Figure 1, then became popular and has been widely accepted as one of the most desirable ways of dissipating heat from the modern engine. This type of system is ideally suited to modern engine and compressor operation because a large quantity of water, at carefully controlled temperatures can be circulated through the equipment. From the standpoint of water caused problems, the small make-up water requirements of the closed recirculating system greatly simplify the situation. The only makeup required is to replace losses from leakage at the pump packing or from drainage of the system for repairs. Little, if any, evaporation loss takes place.

Because the closed recirculating system greatly simplified the water caused problems, it was frequently assumed that no water treatment was necessary. This assumption proved erroneous. Corrosion in closed cooling water systems serving the modern engine can lead to serious problems. As a result of metal loss, leaks often develop which cause loss of cooling water and seriously increase makeup requirements and once again intensify the water problem. The corrosion products that develop often cause plugging of the narrow cooling passages, restrict flow, decrease heat transfer and result in rapid deterioration of the engine.

The metals of construction in the modern engines, compressors, and cooling systems are many and include cast iron, steel, copper, various copper alloys and aluminum as well as solders. Non-metallic components such as natural or synthetic rubber, asbestos and carbon also are involved. Wide temperature variations are encountered up to 180 F or higher and down to ambient (when the engine is off line) with a corresponding variation in oxygen content. The waters used in the cooling system vary in composition with geographical location. Because of these many variables, there is ample opportunity for oxygen pitting, galvanic action and crevice attack. Untreated systems will suffer serious deterioration from these forms of corrosion.

The use of a closed recirculating system does minimize makeup water requirements and therefore the use of softened water, condensate, or even demineralized makeup water becomes economically feasible thus eliminating the problem of scale formation. The low makeup requirements also make it possible to economically treat the system with adequate concentrations of effective corrosion inhibitors.

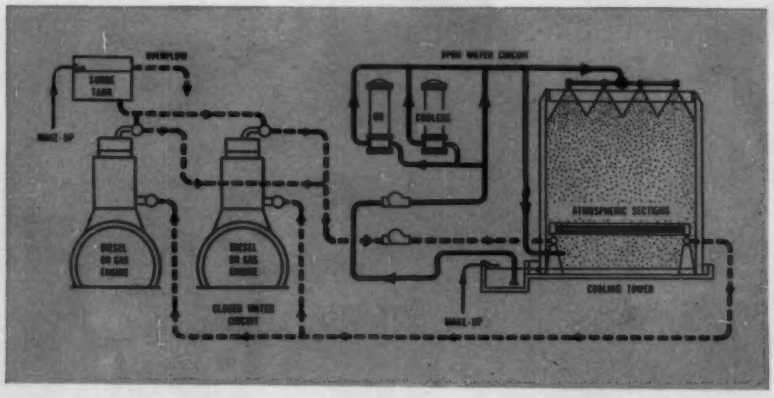


Figure 1—Typical flow diagram of cooling water systems in Diesel or gas engine service. Closed cooling system—dotted lines; Open cooling system—solid lines.

Corrosion Inhibitors for Closed Systems

The three most common types of corrosion inhibitors used for closed cooling water systems are the chromate base materials, the nitrite base materials and the soluble oil inhibitors. Of these three basic types, the chromate base materials are most commonly used. Buffered chromates in the range of 500-1000 ppm are satisfactory for waters low in chlorides and where bi-metallic influences are not encountered. Where chlorides of 100 ppm or more are present, increased con-

centrations of buffered chromate types of treatment may be necessary. Where bi-metallic couples such as steel and copper are also present even greater treatment levels are required on the order of 2000 ppm or more. When aluminum or its alloys are also present the problem of preventing corrosion is even more difficult. The bi-metallic couple most difficult to cope with is that of copper and aluminum. Buffered chromate concentrations of 5000 ppm or more usually are not adequate. It becomes necessary to use other additives such as nitrates or silicates to supplement the chromate base materials.

In closed systems that must be protected against freezing during winter operation alcohols or glycols are often used. While buffered chromates may be used with methyl alcohol anti-freeze solutions, it is essential that the pH be maintained consistently at a high level

CLOSED COOLING SYSTEMS

otherwise reduction of the chromate will take place. Glycol anti-freezes and chromate base treatments are not compatible. The non-chromate type treatments are better suited for handling closed systems containing anti-freezes.

The problem of toxicity of high chromate concentrations on occasion may restrict the use of these materials, particularly when frequent draining of the system is necessary. However, usually provisions can be made to handle situations of this type.

Another problem sometimes is encountered where the use of chromate base materials may not be applicable. Compressor stations that handle gas high in hydrogen sulfide content sometimes are plagued with leakage of the gas from the power cylinder into the water circuit. In these cases reduction of chromate will take place leading to ineffective corrosion control and deposit formation.

The nitrite base materials find frequent use in the treatment of closed recirculating systems, particularly in those situations where the chromate base materials are not applicable. Nitrite is a suitable corrosion inhibitor for iron and steel when the pH value is maintained in the alkaline range. Nitrite is not an effective inhibitor for copper and its alloys and can not cope adequately with couples of these metals with steel. Accordingly, other inhibitors that are specific corrosion inhibitors for copper must be used with the nitrite. When aluminum is also present in the system, the corrosion problem is intensified and nitrates and silicates must be used to supplement the nitrite. The nitrite base treatments are poly-component, and are required usually at considerably higher treatment levels than the chromate base materials. These treatments have the advantage of being compatible with anti-freeze solutions and are less objectionable from the standpoint of toxicity. Their primary use is to handle these situations.

Soluble oils are good corrosion inhibitors and afford excellent protection to ferrous metals, copper and steel couples and are effective even when aluminum is present. Cavitation erosion attack also is controlled effectively by these inhibitors. For the most part soluble oils owe their effectiveness to their polar properties which permit adsorption of a film that acts as a barrier to corrosion. These agents must be used at relatively high treatment concentrations on the order of 1 to 2 percent or higher in some cases.

It is essential that these inhibitors be efficiently buffered and emulsified, otherwise heavy fouling of the cooling system can take place. Serious interference with heat transfer and overheating have resulted under these conditions. It is essential also that natural rubber hoses and gaskets be replaced with synthetic rubber to avoid difficulties with swelling and softening of these components.

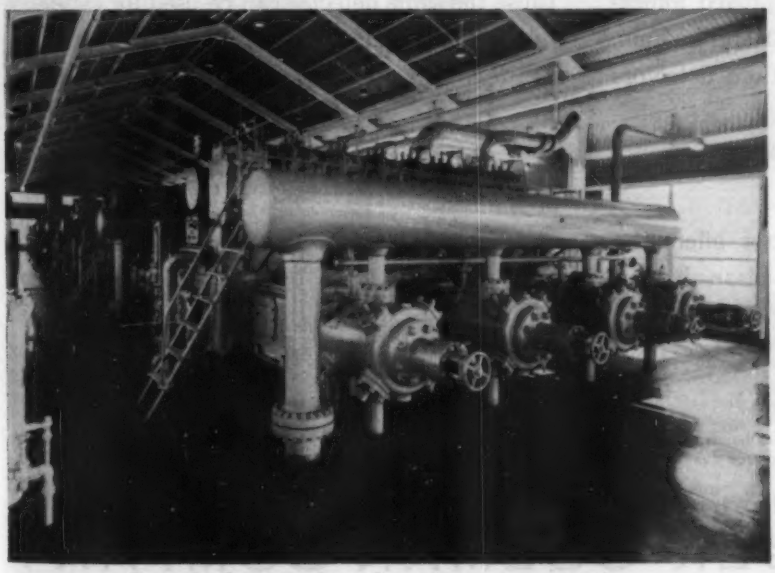


Figure 2—Operating floor of a modern compressor station.

Many new engineering advances have been made by Betz in the treatment of cooling water for compressor and engine jacket systems. The versatility of these methods makes them ideal for eliminating any water-side problem in closed cooling water systems . . . effectively and economically. A Betz Field Engineer will be pleased to discuss your cooling water problem and acquaint you with the savings that can be accomplished through the use of Betz service. A good time to call him in is *now!*

BETZ LABORATORIES, INC.

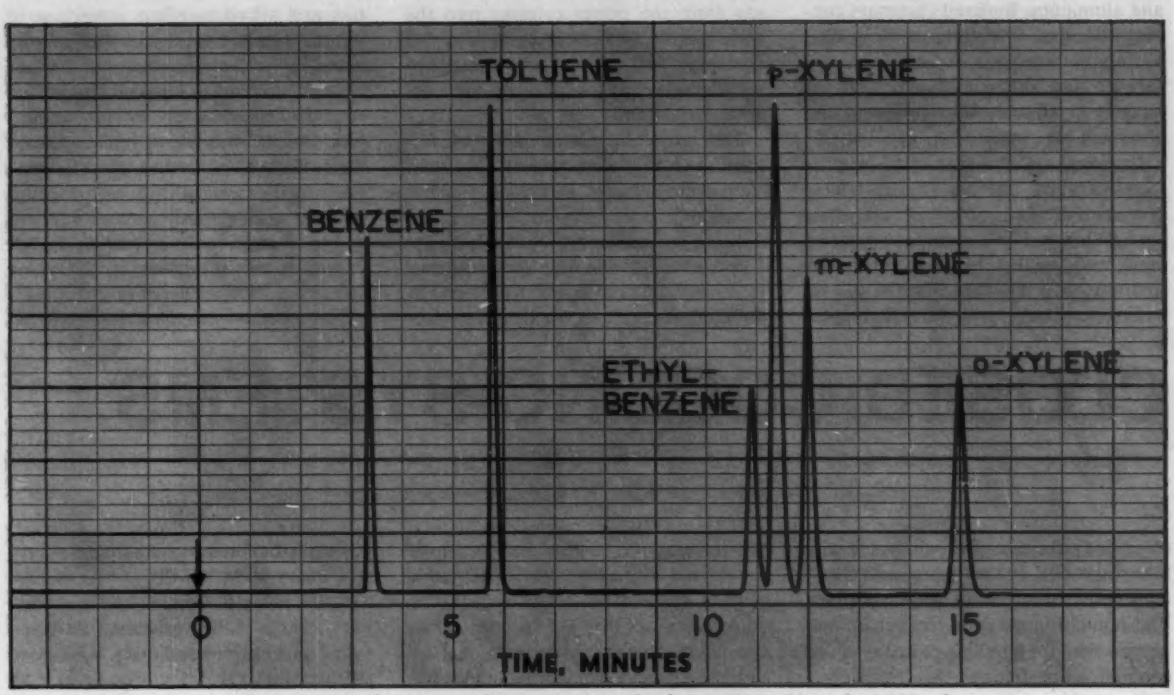
Gillingham & Worth Streets • Phila. 24, Pa.

BETZ

■ CONSULTANTS ON INDUSTRIAL WATER PROBLEMS

Another Wheelco *first*—

New tritium detector means less base line noise, greater sensitivity



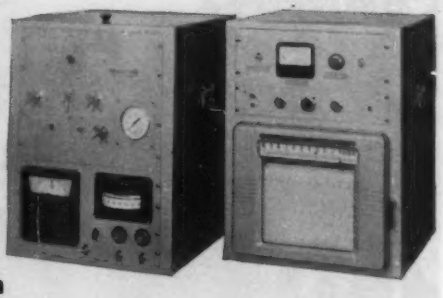
Chromatogram showing complete separation of xylenes using tritium detector and 60-ft stainless steel capillary column. Temperature, 67°C; flow rate, 0.7 ml/min Argon.

Now Wheelco offers a new tritium detector — to 225°C — in addition to the time-proved ionization detectors using strontium 90 and radium. Sensitivity is greater because tritium detectors have less base line noise than any other radioactive source: 1/3 as noisy as strontium and 1/30 as noisy as radium.

With a tritium source the detector offers the ultimate in simplicity and can be cleaned regularly. Long life with practically no maintenance or replacement is assured.

Outstanding operating flexibility is provided because the same detector can be used for capillary or packed columns.

See Wheelco first before selecting any chromatography equipment. New developments based on extensive field experience keep Wheelco ahead of the rest.



Model 20 is a compact, portable unit designed to use both capillary and packed columns. Wheelco also builds the Model 10, a laboratory unit for single or dual operation.

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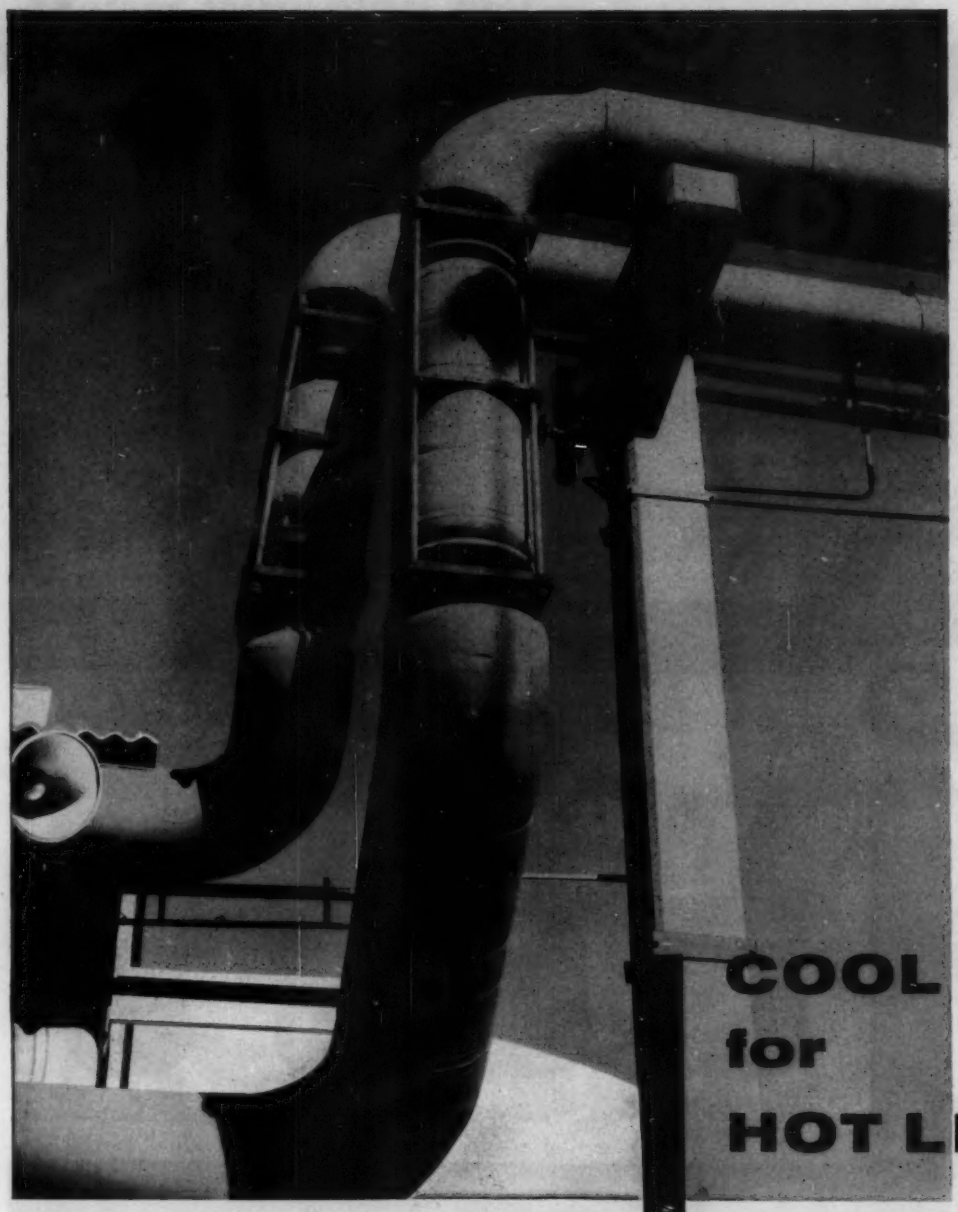
LARKIN LEADERSHIP HAS BEEN EARNED BY YEARS OF DEPENDABLE PERFORMANCE



COOL IDEA for HOT LINES

ADSCO DIVISION

World's Oldest and Largest Manufacturer of Expansion Joints

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Plants and Sales Offices

YUBA CONSOLIDATED INDUSTRIES, INC.

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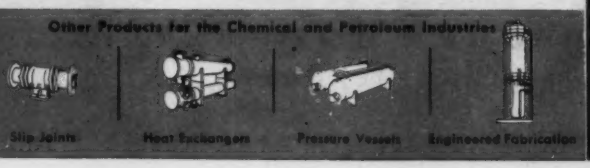


Adsco Corruflex Packless Expansion Joints, of course.

This unusual photograph illustrates the tremendous stresses which must be absorbed in process piping. Adsco Corruflex Expansion Joints are custom-engineered for your particular piping problems.

These joints with stainless steel bellows were designed and manufactured for Callery Chemical Co., Muskogee, Okla., as an integral part of Callery's high-energy fuel plant. Adsco also makes bellows of carbon steel, copper, Hastelloy, Inconel, Monel, nickel, aluminum, and many other metals.

Corruflex Expansion Joints are available in sizes 3" and larger, with sleeves, for temperatures from 400°F below zero to 1600°F and higher, and for pressures from full vacuum to 1000 psi and above. Write for Bulletin 59-50.

For more data on advertised products, use Readers' Service Cards, last page.

1,257,643 HP

OF WORTHINGTON TURBINES NOW DRIVING EVERY MAJOR MAKE OF CENTRIFUGAL COMPRESSOR

More than a million hp of Worthington compressor-drive turbines (and this includes only centrifugal compressor-drive turbines) are now operating around the world. This includes the largest petrochemical unit (we build them up to 50,000 hp), and the fastest (15,000 rpm). There's a "priceless extra" in every Worthington high speed turbine that's behind this remarkable acceptance.

To find out what it is, turn the page ▶

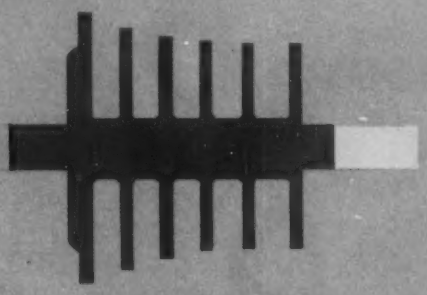
1660 hp, 6783 rpm Worthington turbine driving a Worthington centrifugal compressor at Gulf Oil Corporation's Girard Point Refinery, Philadelphia, Pa.

RELIABILITY

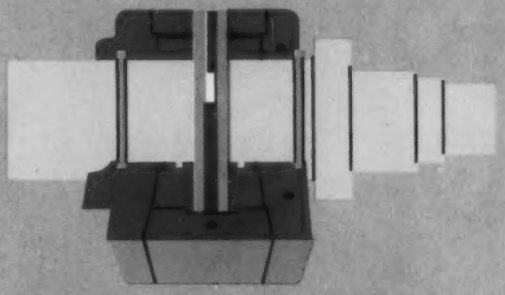
THE PRICELESS EXTRA
IN EVERY WORTHINGTON
HIGH SPEED TURBINE

Reliability is the ultimate goal of every step that Worthington takes in the design and manufacture of compressor-drive turbines. Reliability is the reason for six extra-quality features shown below. Reliability is the end result of infinite attention to engineering detail based on our 32 years experience in this specialized field. Reliability is the reason Worthington load-tests all multi-stage machines. Reliability is the priceless extra—the single most important reason why more compressor-drive turbines, driving all major makes of compressors, have come from Worthington than any other builder. Worthington Corporation, Wellsville, New York. 48-4

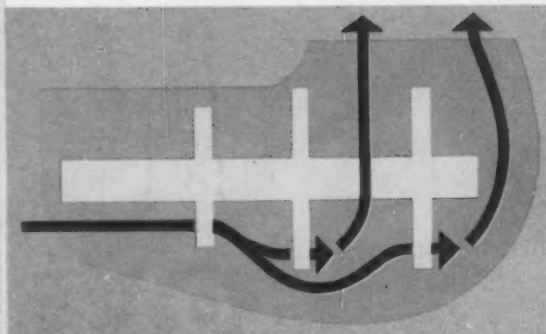
WORTHINGTON



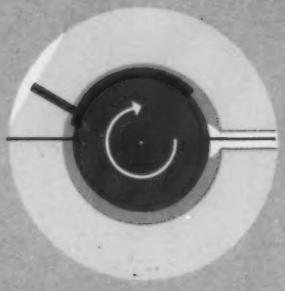
SOLID ROTORS—wheels forged integral with the shaft—provide a more rugged, conservative design.



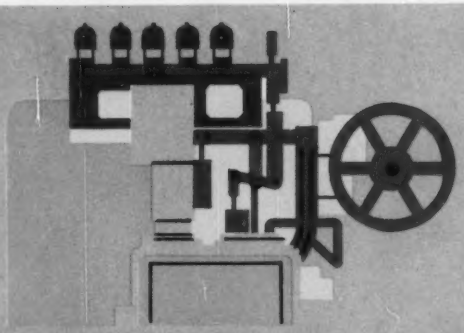
KINGSBURY-TYPE THRUST BEARINGS withstand heavy thrust loads. Shoes pivot, forming a wedge-shaped oil film between thrust collar and bearing surface.



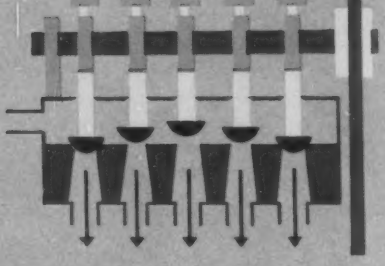
DOUBLE-FLOW EXHAUST—the last stage is divided into two wheels—reduces blade length, increasing efficiency.



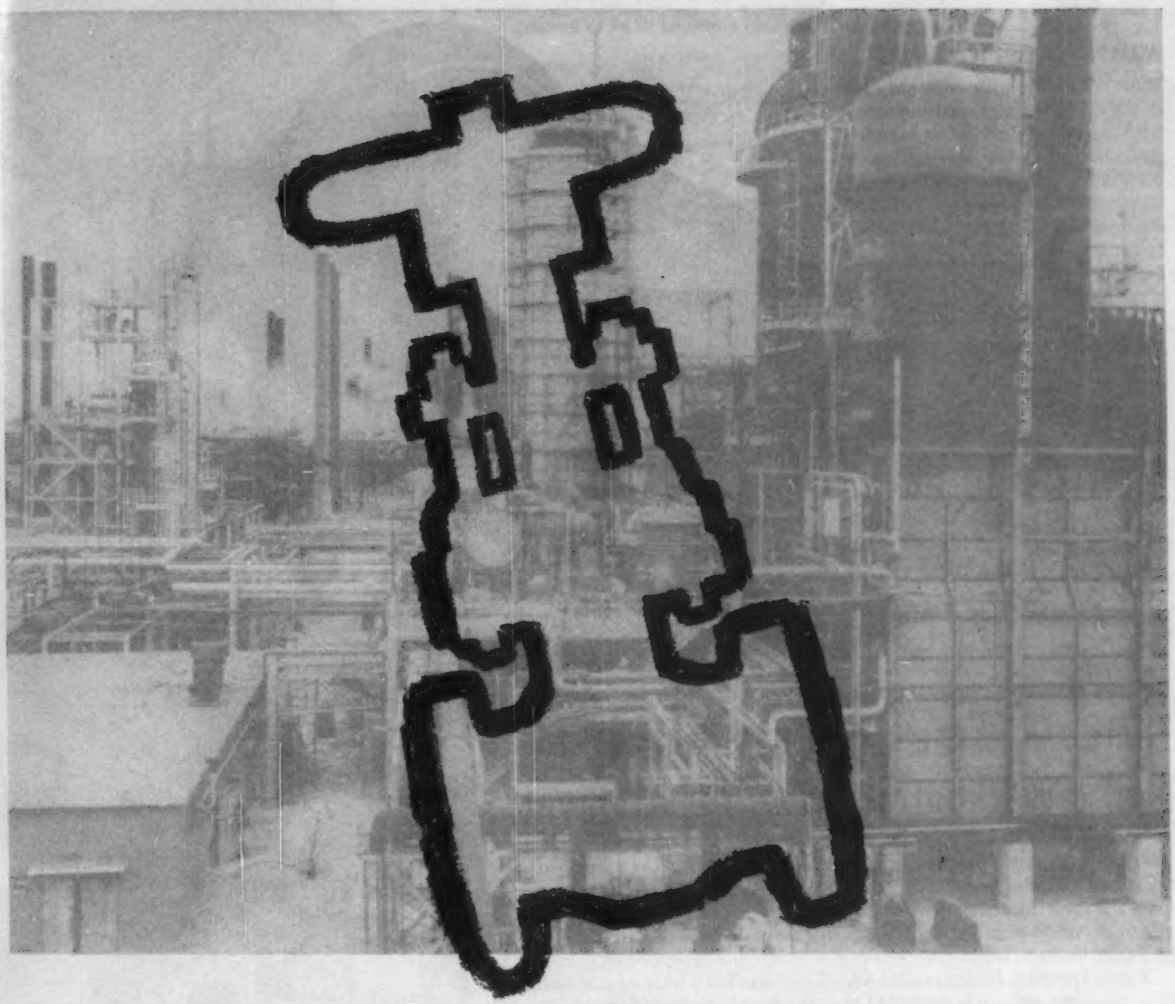
ANTI-OIL-WHIP BEARINGS keep vibration to a minimum. An oil dam in upper half of bearing builds up a pressure pad, keeping rotor firmly in place.



SENSITIVE SPEED GOVERNING SYSTEM provides close control over a wide speed range. (Governor takes air impulses from an outside controller to vary speeds.)



CAM-OPERATED AUTOMATIC NOZZLE CONTROL. Each valve, with separate cam, controls a group of nozzles for maximum economy at all loads.



-Don't ask us who designed the STANCO VALVE!

Frankly, we cannot give credit to any one individual, or even to a group of individuals, for the design of STANCO Valves. They are the end result of a manufacturer — with complete facilities for pattern making, casting, heat treating, machining, assembling and laboratory testing — working closely with leading pipeline and refinery engineers to develop superior valves to solve their particular problems.

STANCO Ductile Iron* Valves are field-conceived, field-tested, and field-proven. They possess the qualities petroleum engineers demand to meet the problems unique to their industry. They have corrosion resistance equal to that of cast iron, elevated temperature strength comparable to that of ordinary cast steels, and thermal shock resistance equal to that of cast carbon steels. And they are *pressure tight*. Ductile iron has a metallographic structure which resists leakage or seepage by liquids and gases.

If you are looking for a better-performing valve, chances are you'll find it in one of the valves we now manufacture. If not, why not tell us your problem?

*Trade Mark of the International Nickel Co.

STANDARD BRASS & MANUFACTURING CO.

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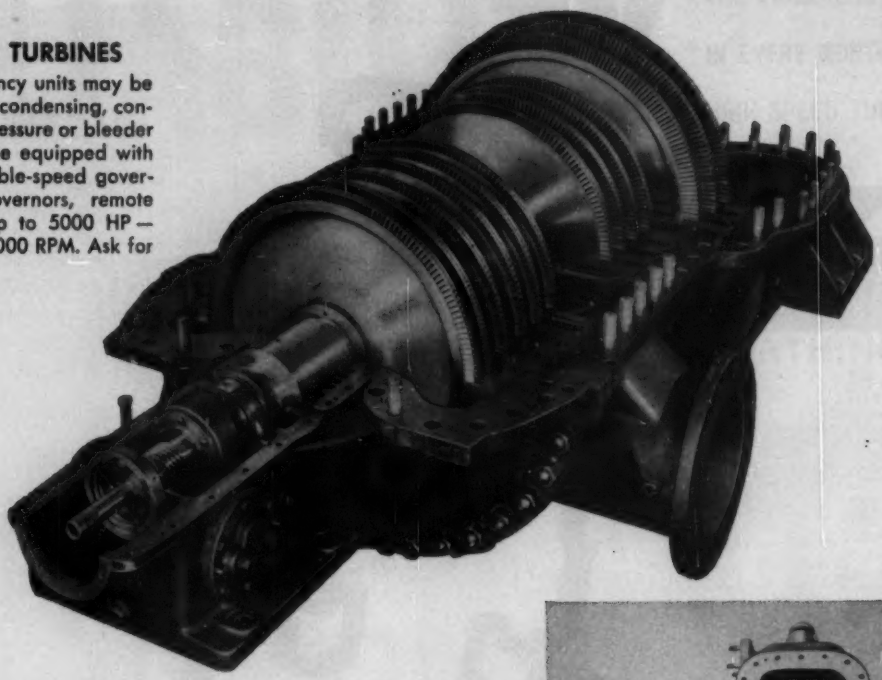
For more data on advertised products, use Readers' Service Cards, last page.

MULTI-STAGE TURBINES

These high-efficiency units may be designed for non-condensing, condensing, mixed pressure or bleeder operation. Can be equipped with constant or variable-speed governors, special governors, remote controls. Sizes up to 5000 HP — Speeds up to 10,000 RPM. Ask for Bulletin S-146.



There's a **Terry turbine** for every mechanical-drive requirement

The designs for Terry turbines are based on more than 50 years of successful experience in the manufacture of turbine drives *exclusively*. This specialization has resulted in Terry becoming one of *the leading producers* of mechanical-drive turbines in sizes up to 5,000 horsepower.

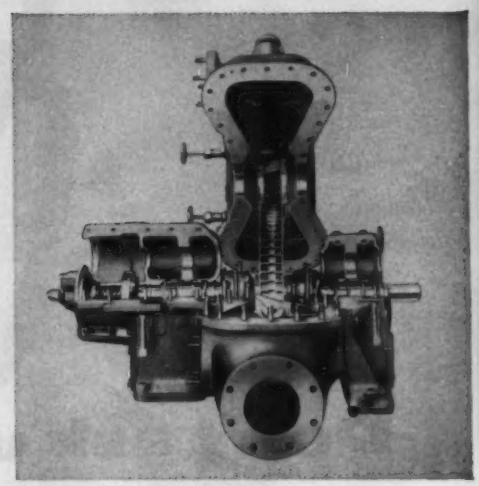
There are three basic reasons why Terry has been able to maintain this position of leadership: (1) a thorough knowledge of the requirements of mechanical-drive turbines, (2) a willingness to build "a little something extra" into each machine to assure trouble-free operation, and (3) an acknowledgement of the company's responsibility to stand behind the performance of every turbine sold.

These are also the reasons why you should consider a Terry turbine for your next mechanical drive. In the meantime, send for bulletins describing any of the types of machines illustrated.

THE TERRY STEAM TURBINE COMPANY
TERRY SQUARE, HARTFORD 1, CONN.

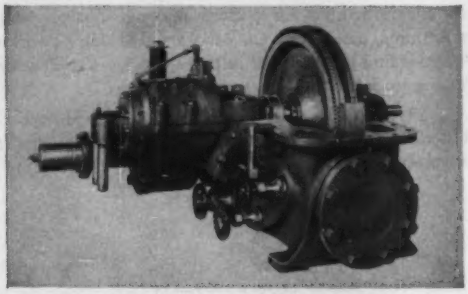
TERRY

TT-1209



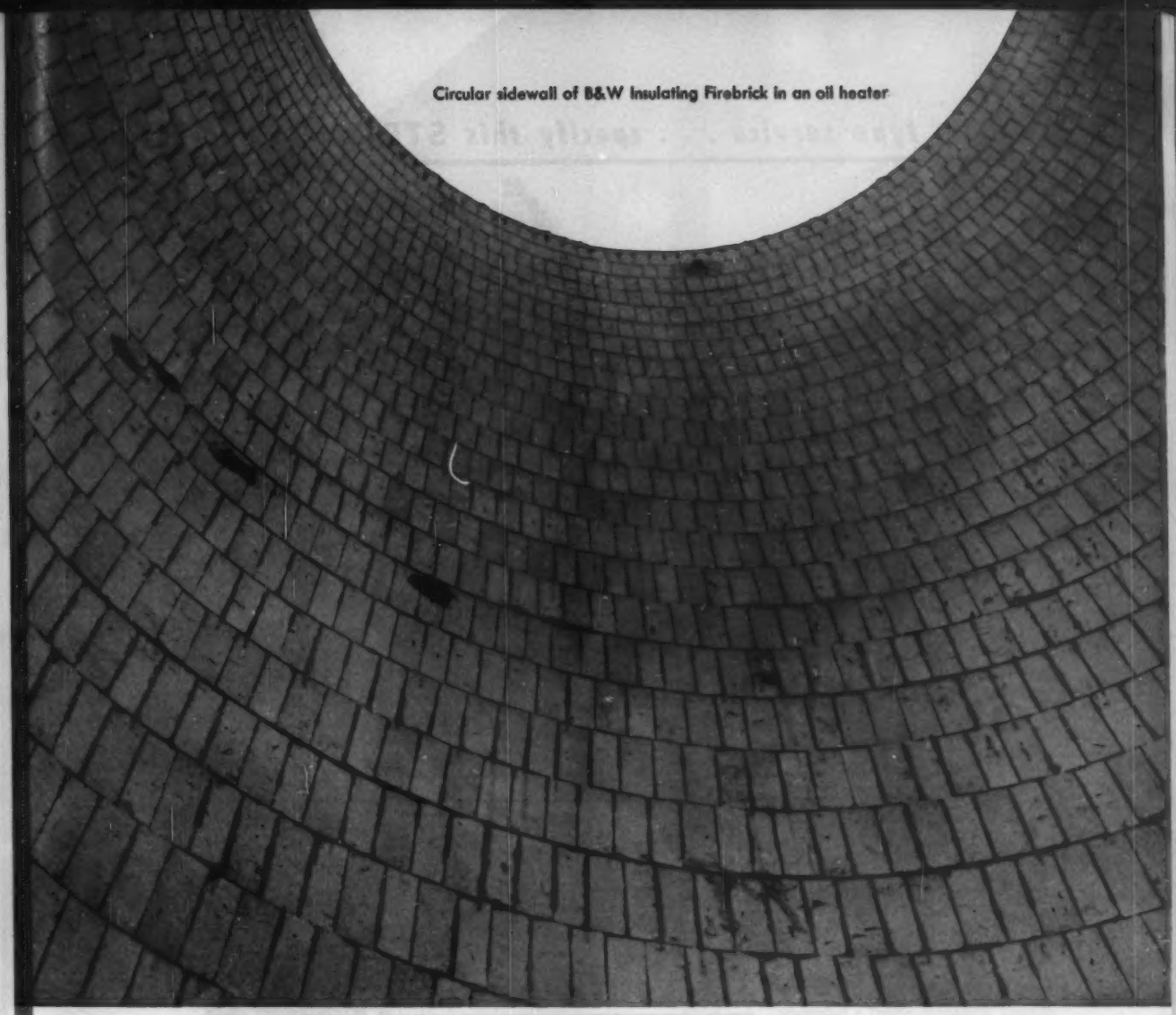
SOLID-WHEEL TURBINES

Famous for sure dependability and ease of inspection. Can be started cold — no preliminary warming required. Available in vertical designs depending on frame size. Capacities from 5 to 2,000 HP. Described in Bulletin S-116.



AXIAL-FLOW IMPULSE TURBINES

Built with one, two or three rows of high-grade stainless steel blading, these turbines combine efficiency with durability. Available in designs for moderate and high steam pressure. Bulletin S-143.



Circular sidewall of B&W Insulating Firebrick in an oil heater

How B&W Insulating Firebrick cut processing costs

Here are four *key* reasons why B&W Insulating Firebrick reduce over-all costs in chemical and petroleum process furnaces:

High Hot Load Strength —B&W IFB provide maximum load-bearing capacity *under operating temperatures.* Many oil heaters have been built with walls 80 feet high *with no intermediate support.*

Low Heat Storage — Cost-cutting B&W IFB have the *lowest* heat storage of any insulating firebrick. Since B&W IFB cool off fast, they protect expensive alloy tubes in the event of forced shut-down . . . make possible quick access to the furnace for inspection. They also reach operating temperature quickly, reducing cycle time and fuel bills.

Long Life — B&W Insulating Firebrick are *long* lasting because of the exceptional refractory nature of their base ingredients and the high processing temperatures to which they are subjected during manufacturing.

Short Installation Time —You save materially with B&W Insulating Firebrick because they are machined to size. They may be modified to fit door openings, peepholes, and other special conditions because they can be cut, drilled or shaped on the job with ordinary woodworking tools.

These sound reasons explain why process furnace builders and operators specify B&W Insulating Firebrick. Learn how these lightweight brick can help you save money. Your B&W representative will be glad to give you facts and figures.

B&W REFRACTORIES PRODUCTS:
B&W Alimul Firebrick • B&W 80 Firebrick • B&W Junior Firebrick • B&W Insulating Firebrick • B&W Refractory Castables, Plastics and Mortars • B&W Silicon Carbide • B&W Ramming Mixes • B&W Kaowool

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WORKS: AUGUSTA, GA.

R-616

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Dirty Lines or Dirty Steam:

Lowest Initial Cost per pound capacity:

Lowest Initial Cost per pound weight:

Eliminating Large Volumes of Air:

Low Pressures with some air elimination:

Pulsating or Widely Varying Pressures:

Continuous flow required:

Draining a line carrying a vacuum discharging to atmosphere:

Draining a line carrying a vacuum or very low pressure discharging against a hydrostatic head or back pressure:

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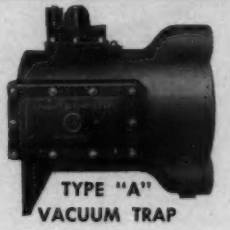
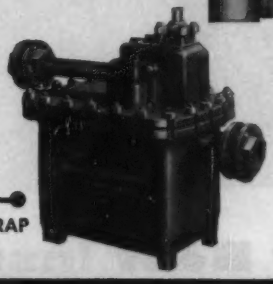
FLOAT & THERMOSTATIC TRAP

OPEN BUCKET TRAP

BALL FLOAT TRAP



TYPE "A" VACUUM TRAP



TYPE "M" VACUUM TRAP

on every type service STRONG steam traps give you longer life, less maintenance

Strong offers six types of steam traps to answer every requirement for removing condensate from all types of systems.

You can specify these Strong Traps with the assurance that you will get maximum service life. Proof is the fact that replacement parts are still being ordered for traps sold 50 years ago!

Here are some low maintenance features built into Strong Traps. Screwed-in, replaceable valves and seats of wear-resistant ANUM-METL. Deep-drawn, one-piece stainless steel buckets. Extra-heavy body and cover construction. Thorough testing. Interchangeable parts.

You will be money and years ahead when you specify Strong Traps. For further information, contact your local Strong distributor — he carries complete stocks and replacement parts, offers prompt service.

Selector Chart in Strong Catalog No. 69A gives trap recommendations for 45 types of equipment. Write for your copy or call your distributor.

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steam traps • air traps • float traps • vacuum or pumping traps
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U.S. UNIBASE pump motor

...with exclusive MICROSET coupling

Designed to simplify pump maintenance and minimize down time in industrial short-coupled service, the new U.S. UNIBASE MOTORS make it easy to handle the replacement of pump seals and other recurring maintenance operations. Large side opening gives unhampered access to coupling. Ingenious coupling spacer arrangement eliminates necessity of dismounting motor to replace pump seal. Exclusive U.S. MICROSET COUPLING makes accurate fine adjustment of pump impellers quick and simple without coupling disassembly. Rigid, rugged UNIBASE is *one integral package*, factory tested for true alignment and concentric mounting... and delivered as a unit. UNIBASE MOTORS available in Type HV-1, dripproof, 7½ to 125 H.P.; Type JV-1, Totally-Enclosed; Type EV-1, Explosion-Proof. For short-coupled turbine pump applications, specify: "U.S. UNIBASE MOTORS."

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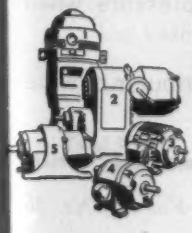
For Full Information, send for Unibase Bulletin No. F-1975



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U.S. MAJOR MOTOR LINES INCLUDE:
1. Vertical Solid & Hollowshaft, 2. Varidrive, 3. Totally-Enclosed, 4. Uniclosed, 5. Syncrogear. Also, many other special motors.

POWELL
FOR CORROSION RESISTANT VALVES

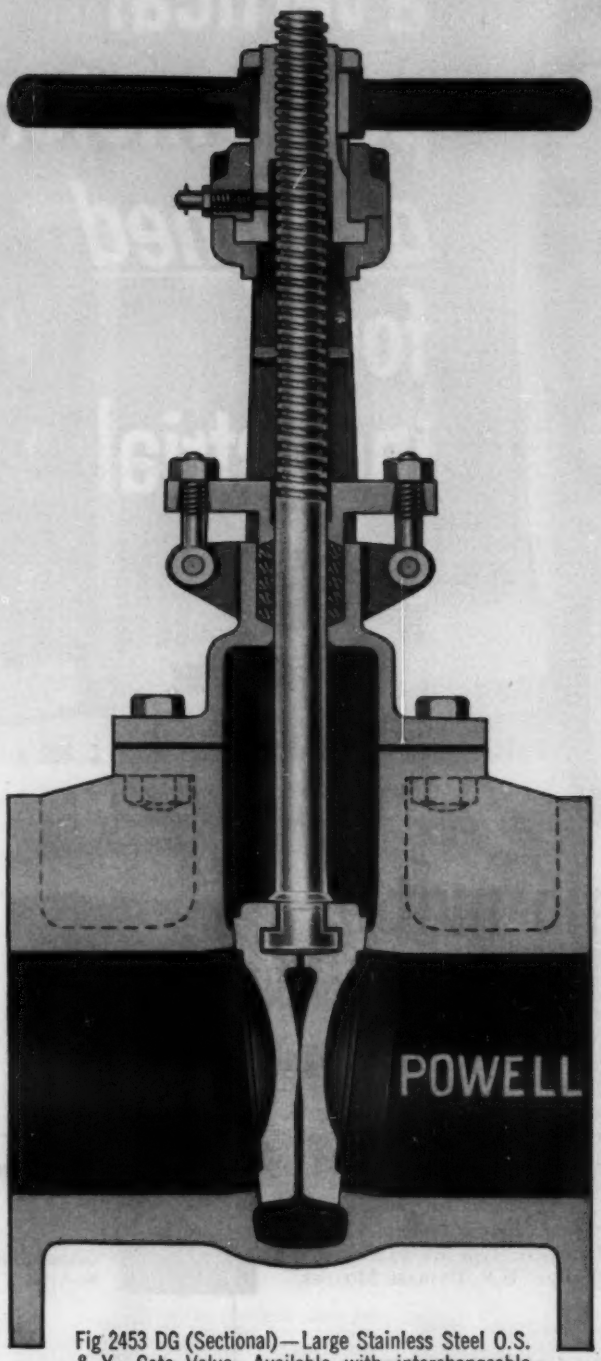

Fig 2453 DG (Sectional)—Large Stainless Steel O.S. & Y., Gate Valve. Available with interchangeable solid or split wedges. Wedges are fully guided throughout their travel.

Fig. 2633—Large, Stainless Steel Swing Check Valve for 150 W.P. Sizes, 2" to 12".

Powell offers valves available in the largest selection of metals and alloys to handle practically every corrosive fluid—valves that can be depended upon to control flow in most severe services—because of

Powell advanced design and engineering.

Solid and double wedge discs of gate valves are interchangeable. They are precision machined and fitted, and are accurately guided throughout their entire travel. This prevents drag of the disc over the seat faces, eliminating wear of seating surfaces and stops undue vibrational noises.

O.S. & Y. Valves—Stems are threaded and guided through a bronze bushing in upper yoke. (Bushings made of other alloys can be supplied on special order.) A compression lubricant fitting in upper yoke is provided to lubricate the stem and bushing threads and to reduce wear. A convenient shelf is cast on the inner sides of yoke arms for suspending the gland when renewing the packing.

All 150# valves are regularly packed with Teflon Packing. Globe, Angle and "Y" valves are available with metal or Teflon discs.

Globe, Angle, Gate and "Y" valves are back seated for repacking under pressure when fully open.

Consult your local Powell distributor or write directly to us.

THE WM. POWELL COMPANY • *Dependable Valves Since 1846* • **Cincinnati 22, Ohio**

COREXIT stops internal corrosion--reduces maintenance costs . . .

At a cost as low as 50¢ per thousand barrels of throughput, Humble's COREXIT corrosion inhibitors will give you up to 98% protection.

You save money, because COREXIT lengthens the life of expensive equipment, prolongs refinery runs between costly turn-arounds, cuts non-productive downtime to a minimum and promotes increased thermal efficiencies.

Injected into the product stream, COREXIT establishes a durable protective film on internal metal surfaces. This film effectively protects against the causes of corrosion. COREXIT also prevents fouling.

Use COREXIT . . . You'll see a substantial cut in your maintenance costs!

COREXIT is readily available in 55-gallon drums and in bulk. Call your nearest Humble bulk plant, or phone or write:

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HUMBLE OIL & REFINING COMPANY HUMBLE

Expansion Joint Design Moves out of the "Model T" Era

Badger first began fabricating packless metal bellows expansion joints more than 35 years ago. These "Model T" joints performed (and are still performing) with outstanding success in hundreds of process and steam line piping installations.

Starting in the 30's other expansion joint manufacturers entered the field. The most successful adopted many of the basic features of the original Badger design.

During the last decade, as industry's requirements became more stringent, and joint manufacturers gained fabricating and field experience, certain fundamental problems inherent in the early designs became evident. Most of these problems were solved through a series of modifications. (Among which was the Badger Directed Flexing Self-Equalizing Joint — the famous "DFSE" Design.) But, at best, the modifications were stop-gap measures which complicated the joints and greatly increased their weight. A fundamental reassessment of expansion joint engineering data was needed. Badger led the way: In 1956, a task force completed a three-year research program and the first S-R (Service-Rated) Expansion Joints were produced.

In the three years they have been available, S-R Expansion Joints have been both an engineering and a sales success. But like many revolutionary concepts which upset tradition, the full implication of the advantages S-R Joints offer is still not universally understood. The message that follows is an attempt "to set the record straight."

• • • • •

Equalization — fact and fiction

Many users of expansion joints are under the impression that the so-called "equalizing" rings on today's conventional type expansion joints distribute movement equally among all the corrugations of the bellows. It is argued that as the joint absorbs thermal movement, the tops of the rings progressively come into contact until the bellows is fully compressed thus limiting the amount of compression which any one corrugation can ultimately absorb (see diagram 1). In *this* sense the rings do contribute to the "equalization" of movement by physically limiting the compression of each corrugation to the distance between any two adjacent rings.

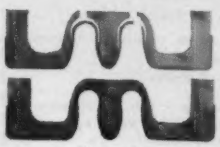

Diagram 1

Conventional Type Expansion Joint. Cross-sections of rings and bellows of a conventional "self-equalizing" joint showing cold and hot positions. Note that true equalization of movement can only be obtained when tops of all rings are in contact — an impractical and dangerous situation.

Note, however, that the degree of compression will not be truly equalized until the tops of all the rings are in contact. But, when such a condition occurs, serious problems will result. If the limit of compressibility is reached before the thermal expansion has been completely absorbed, exceedingly large forces will be transmitted through the pipe line to the anchors and connected equipment. On the other hand, if the joint is compressed only partially, not all of the corrugations will absorb movement to the same degree.

How S-R Joints solve equalization problem

Badger S-R Expansion Joints feature the new Curvilinear Corrugations which naturally assume an "all curve" shape under pressure (diagram 2), assuring more equal distribution of stresses throughout the bellows material. Furthermore, the shape, height and pitch of the corrugations are based on a carefully engineered correlation. Thus, reasonably equal distribution of movement among the corrugations is obtained, even in joints not equipped with reinforcing rings.

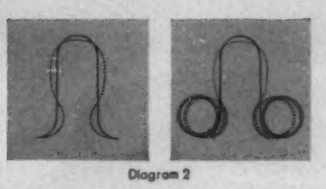

Diagram 2

Badger S-R Expansion Joint. Cross-sections of S-R Joints (Series 50 left, Series 150 right). The movement of the corrugations is shown by dotted and solid lines. Compare configuration and effective height of corrugations, position and size of rings with conventional joint.

Equalization of movement is inherent in the design and functioning of the bellows on Badger S-R Joints. On the basis of provable engineering criteria, the prime purpose of reinforcing rings of any design is to retain the hoop dimension (diameter) of the corrugations when they are subject to internal pressure. This Badger's simple, lightweight tubular reinforcing rings do. But, in addition, the new tubular shape of the rings does contribute to joint flexibility and life by permitting flexing over a more effective portion of the total corrugation height than conventional cast or fabricated equalizing rings.

Better performance, lower cost

Briefly, then, Badger S-R Joints alone offer these advantages: Better equalization of movement which results in elimination of localized stresses and leads to longer joint life; a simple, lightweight design that makes installation easier, eliminates cumbersome castings and fragile mechanical devices; complete range of sizes from 3" to 72" made from any workable metal and with a wide choice of accessories.

Badger S-R Joints are probably the answer to your problem. There's an easy and quick way to find out — ask the Badgerman for his recommendations. Write or phone today. Badger Manufacturing Co., 230 Bent St., Cambridge, Mass.

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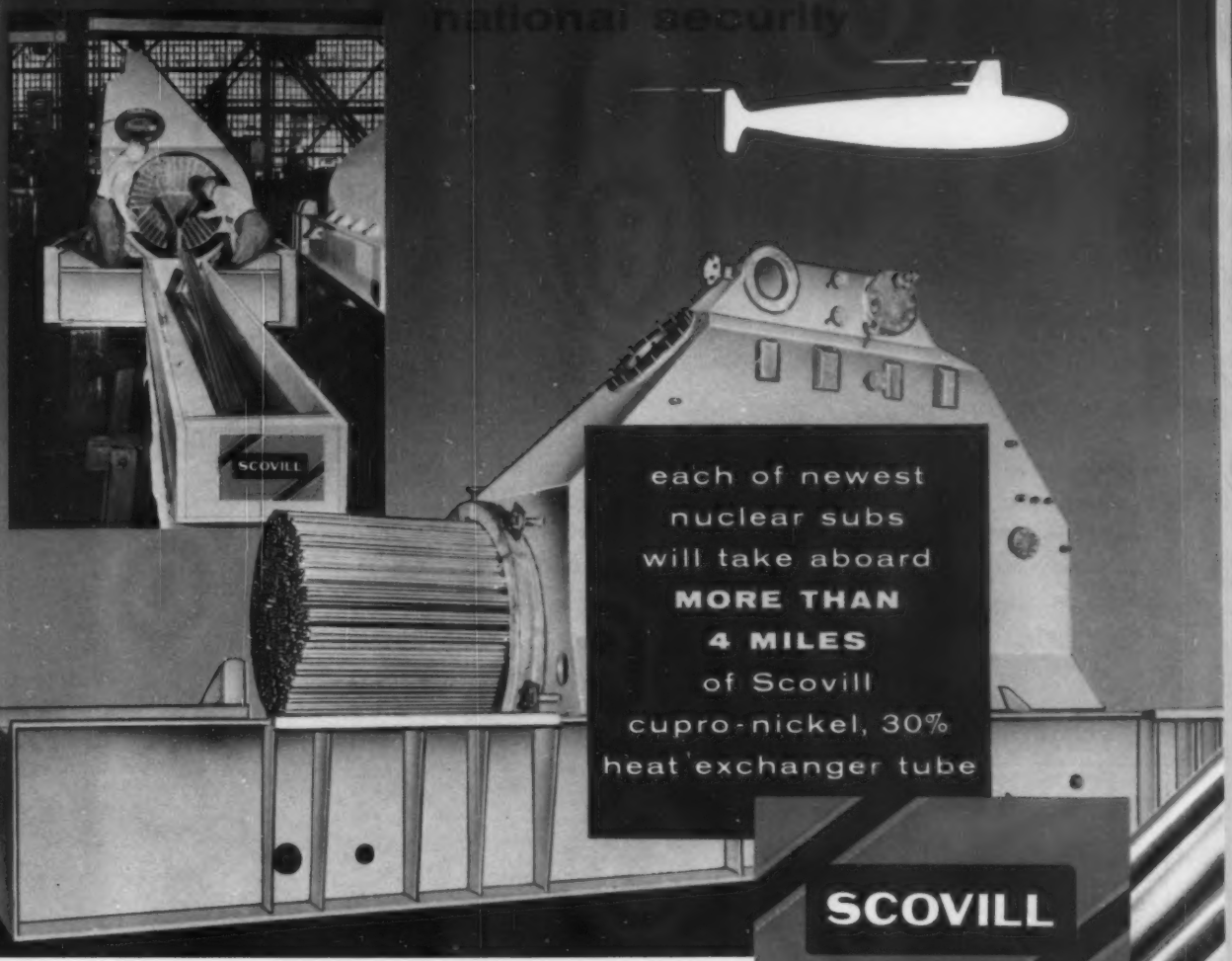
BADGER S·R EXPANSION JOINTS

where trouble-free performance is a matter of national security



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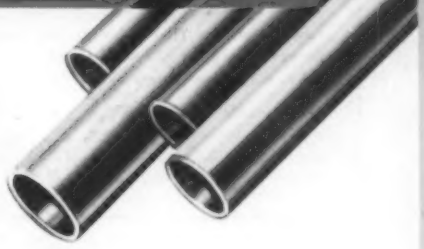
We're proud to be making this important contribution to the long-service dependability of these nuclear-powered submarines.

Like all other components of their nuclear-powered propulsion machinery and equipment, the Foster Wheeler main condensers, shown above being tubed with Scovill Cupro-Nickel, 30% Heat Exchanger Tube, have passed the most exhaustive performance tests it has been possible to devise. The same tube specification is also being installed in the ejector condensers. All of the tube is electronically tested on new equipment at the Scovill Tube Mills before delivery.

Scovill Cupro-Nickel, 30% Heat Exchanger Tube has a long record of trouble-free service on U. S. Naval vessels and those of many other nations. It is a first choice of design and operating engineers where salt water or corrosion conditions are severe, particularly at elevated temperatures and when the circulating media travel at high velocities. The corrosion resistance is excellent; strength of the alloy remains constant over a wide temperature range.

Why not discuss your own heat exchanger tube conditions and problems with Scovill Technical Service . . . considered by many the most experienced in the field.



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repeat business . . . **3 MAJOR EXPANSIONS AWARDED TO BROWN & ROOT**

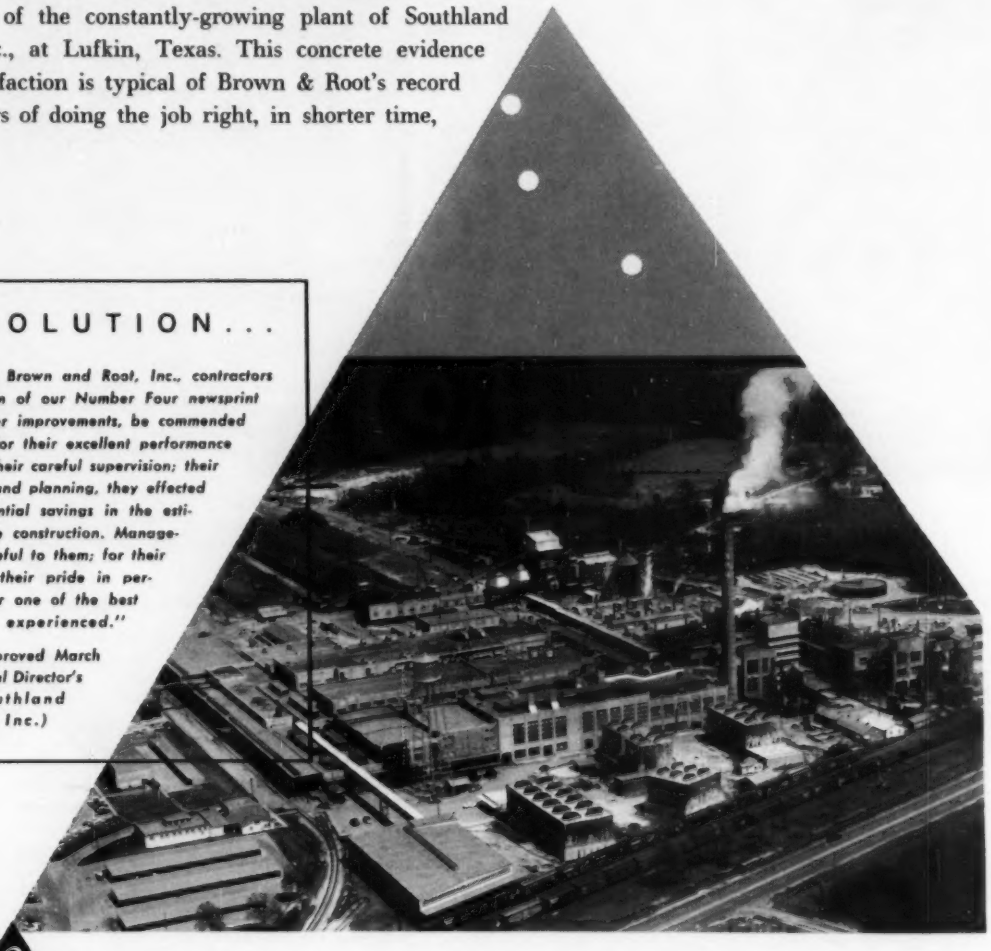
in eleven years

In 1946, and again in 1955 and 1957, Brown & Root was called in for construction of the constantly-growing plant of Southland Paper Mills, Inc., at Lufkin, Texas. This concrete evidence of customer satisfaction is typical of Brown & Root's record through the years of doing the job right, in shorter time, at lower costs.

A RESOLUTION . . .

"RESOLVED, That Brown and Root, Inc., contractors for the installation of our Number Four newsprint machine and other improvements, be commended by Management for their excellent performance rendered us. By their careful supervision; their fine engineering and planning, they effected us a very substantial savings in the estimated cost of the construction. Management is very grateful to them; for their cooperation, for their pride in performance, and for one of the best jobs we have experienced."

(Unanimously approved March 31, 1959 at annual Director's Meeting of Southland Paper Mills, Inc.)



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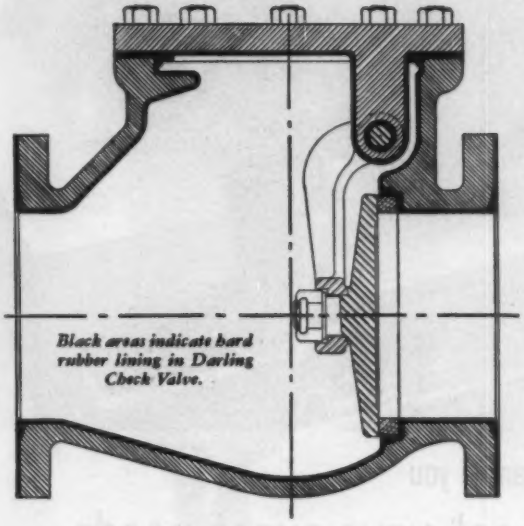
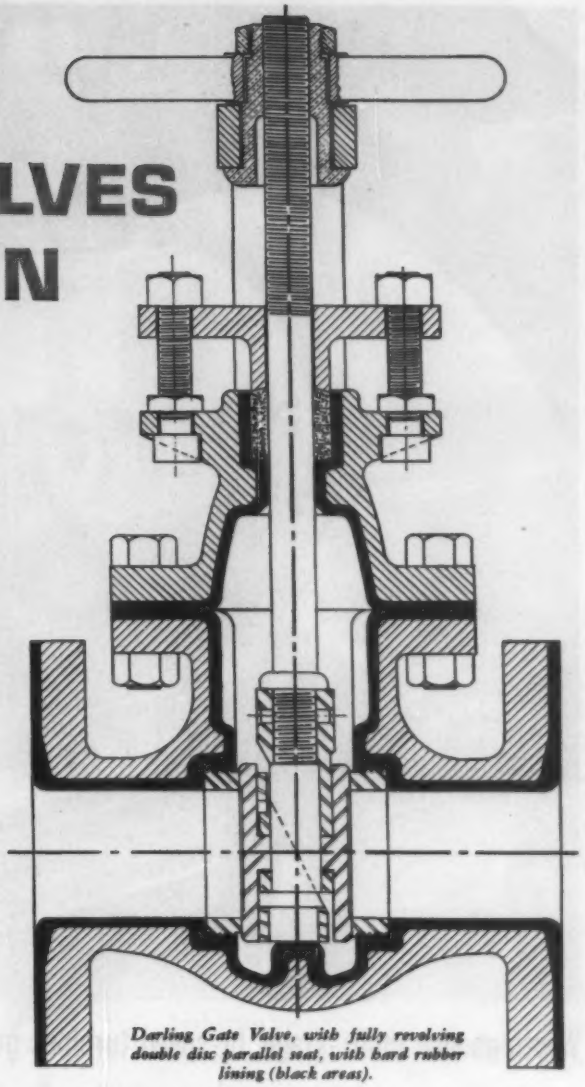
IRON BODY VALVES CAN WORK IN CORROSIVE SERVICE



Black areas indicate hard rubber lining in Darling Check Valve.



Darling Gate Valve, with fully revolving double disc parallel seat, with hard rubber lining (black areas).

Rubber-Lined Check Valves...Gate Valves

Here's a way to make substantial savings in valves for corrosive or abrasive service. Darling Iron Body Check Valves and Gate Valves may be obtained with special hard rubber linings. This means you can often save the cost of expensive special alloy valves, yet obtain high resistance to corrosion or abrasion.

Darling Check Valves employ a streamlined body design especially selected for application of hard rubber lining. Excess area through the valve minimizes abrasion and insures full delivery of line capacity.

Darling Rubber-Lined Gate Valves give you the advantages of the revolving double disc parallel seat and "no pocket" discs... which provide positive sealing and assure ease of operation. Available in outside screw and yoke type, in sizes from 2" to 24". Write for further information.

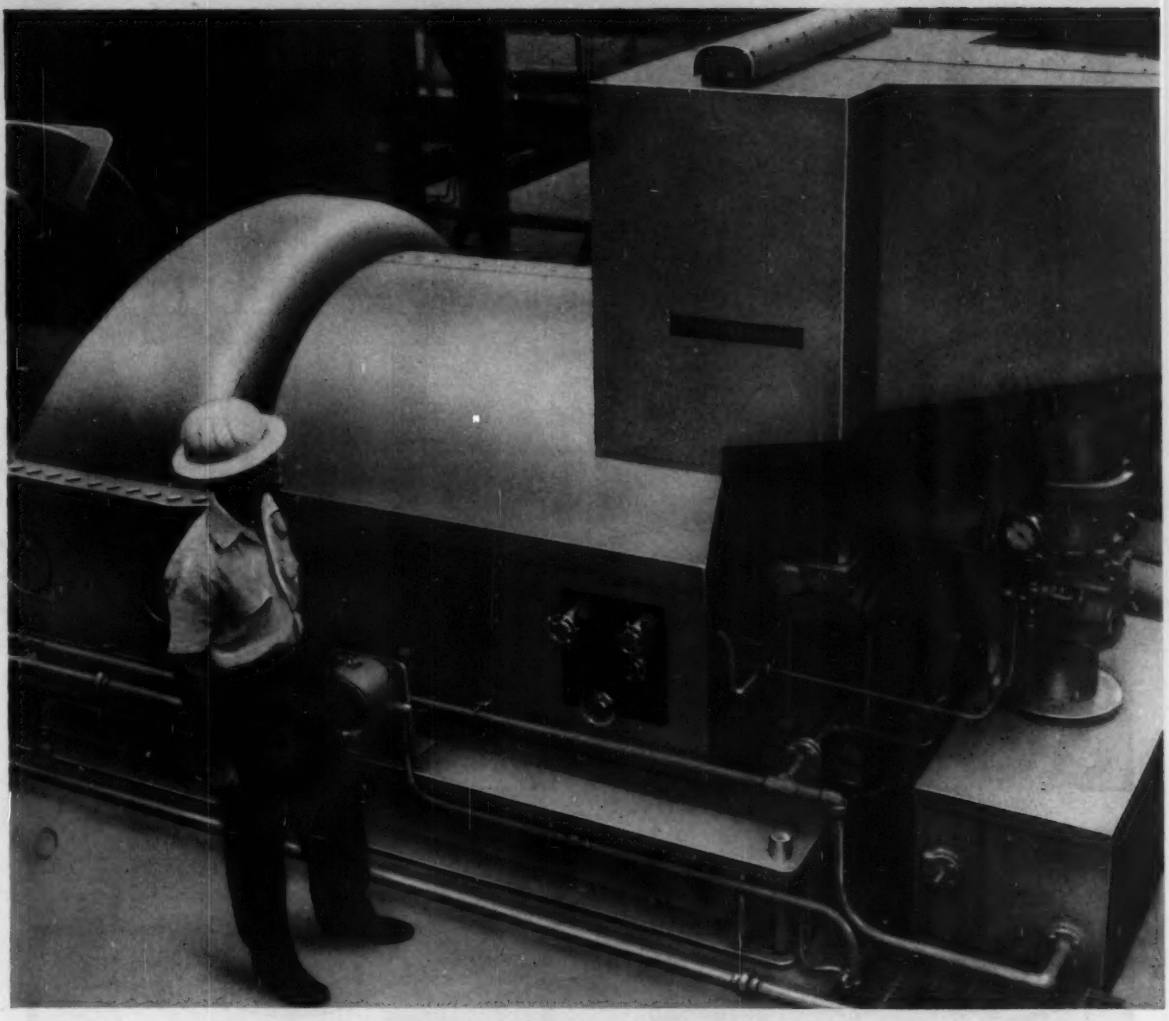
DARLING VALVE & MANUFACTURING CO.

Williamsport 31, Pa.

Manufactured in Canada by Sandilands Valve Manufacturing Co., Ltd., Galt 19, Ont.

DARLING VALVES

For more data on advertised products, use Readers' Service Cards, last page.



Westinghouse multi-stage, hi-speed turbines guarantee you

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Wheel Size, in.	12½	16	20	25	32
Maximum hp	4000	5000	7000	10,000	16,000
Maximum rpm	16,000	12,500	10,000	8000	6000
Maximum P_1, psig	1500	1500	1500	1500	1500
Maximum T_1, °F IT	950	950	950	950	950
Maximum P_2, psig	300	300	300	300	50
Exhaust Size, in.	20	24	30	36	48
D. F. Exh. Size, in.	30	36	48	42 x 64½	48 x 84
Max. Inlet Size, in.	5	6	8	10	12

(For special applications, inlet steam conditions to 2400 psig, 1050° F total temperature can be accommodated.)

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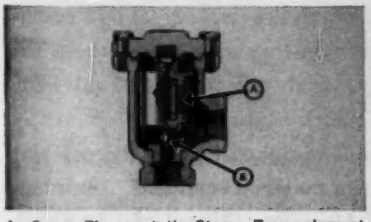
Full-range steam traps cut high cost of steam pressure variations

By John W. Ritter, Test Engineer
SARCO Company, Inc.

While boiler room economics dictate that boiler pressures remain constant, the equally sound economics of batch processing may decree that pressures at the equipment vary with the requirement of the process. The attempt to choose a steam trap that is all things to all conditions may result in installing traps that operate inefficiently at either extreme of their pressure range or that require adjustment every time the operations sheet calls for another pressure-temperature setting. Orifice traps represent a somewhat more rational approach to the problem, but often at the price of a continuous discharge of steam, particularly at the low pressures of start-up and shut down. Compromise, adjustment, and steam waste all spell inefficiency in the utilization of steam.

Production-Planned steam trapping, on the other hand, improves efficiency by the use of properly designed and installed thermostatic steam traps. Such traps employ the expansion and contraction of a thermostatic element to operate the discharge valve.



In Sarco Thermostatic Steam Trap, element (A) expands at steam temperature to close valve (B), contracts to permit discharge of condensate.

In the Sarco "Balanced Pressure" Thermostatic Steam Trap a volatile fluid is sealed inside a metal bellows that opens or closes the valve as it contracts or expands with condensate temperature. Near steam temperature, evaporation of the fluid creates an internal pressure greater than steam pressure in the trap body, and the expanding bellows seats the valve. When the condensate cools, the element contracts and opens the valve.

It is evident that at steam temperature pressure inside the element is higher than steam pressure, no matter how the latter may vary. Thus, the trap compensates automatically for variations in pressure.

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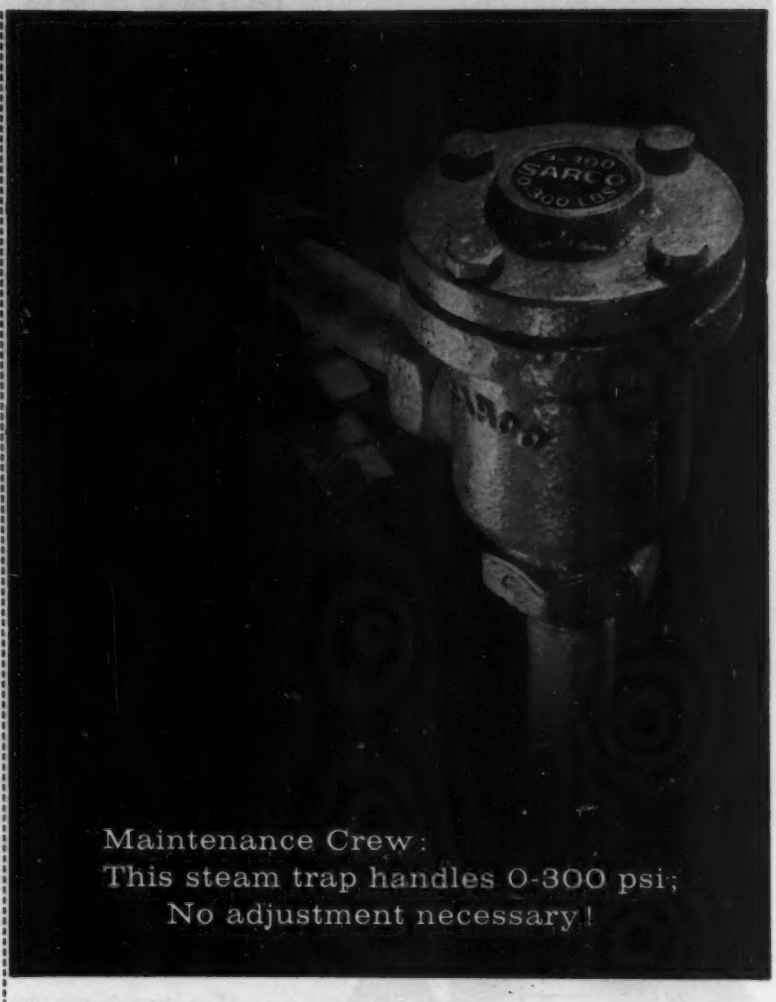

Sarco "Balanced Pressure" Thermostatic Steam Traps cut trap maintenance costs and simplify parts inventory. Why? Because the same bellows, head and seat handle steam pressures up to 300 psi – without any need of adjustment for variations in load or pressure.

Other advantages: unmatched capacity/cost ratio (1" size discharges 9,650 lbs/hr. at 10°F below steam temperature, 125 psi). This trap can't air-bind and, when installed with free discharge, can't freeze.

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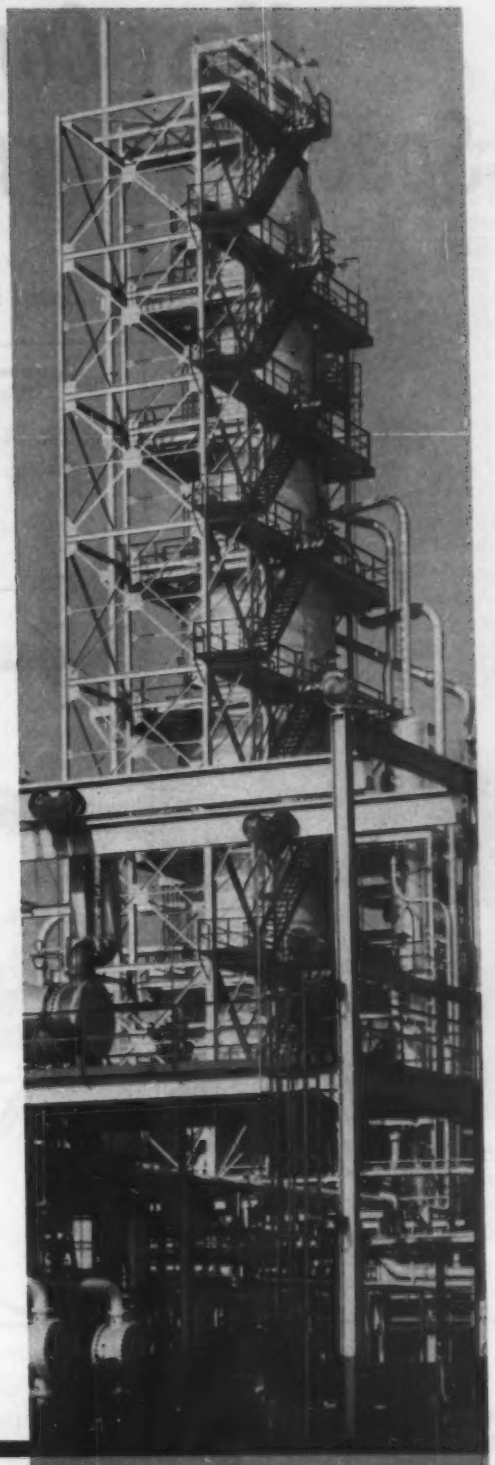

Six months back, one West Texas refinery had put to work at turnaround time the ECP* developed by the Oakite man. It included cleaning the sour crude unit throughout. Results were visibly excellent. Refinery personnel felt they had cleaned exchangers and towers as never before. Now, after six months, operating record has confirmed that opinion.

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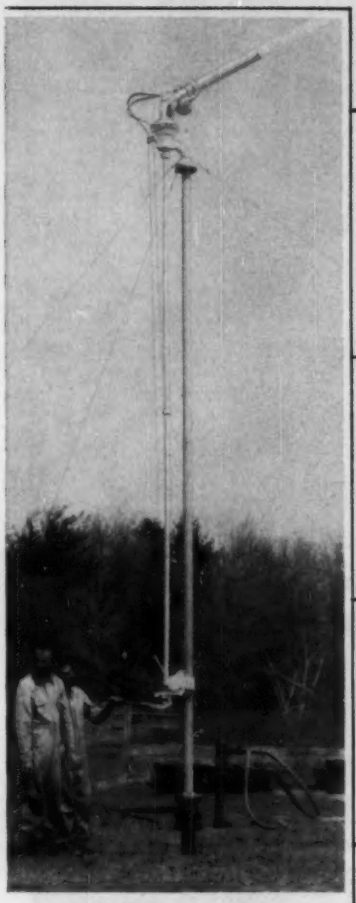
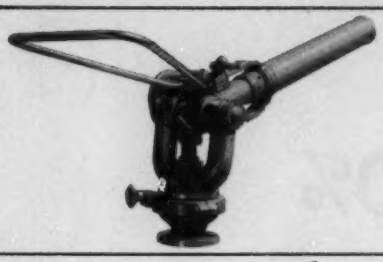
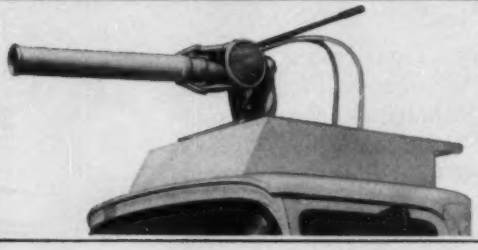


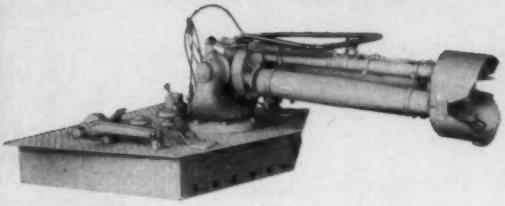
Extended Manual Control Type — Turret nozzles extend 10 to 20 feet above remote control station on deck or ground on standard units . . . greater remote extensions for special applications.



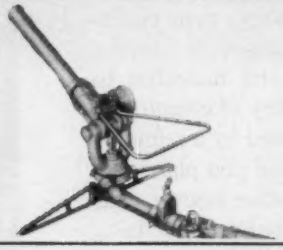
Direct Manual Control Type — Gives fire fighters "out-in-the-open" control from cab roof!



Remote Manual Control Type — Easily handled by man in driver's seat. Ideal for fast action!



Remote Hydraulic Control Type — Power-controlled from within the cab. Single and dual models. Widely used on air crash rescue fire-fighting trucks.



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SOME FACTS AND FALLACIES ABOUT PACKED TOWERS

☑ **Packed towers are practical in diameters over 3 ft.**

TRUE. Modern tower packings, such as "Intalox"® saddles and metal Pall Rings have made an old "rule-of-thumb" obsolete. Formerly, engineers were hesitant to use packed towers over three feet in diameter, especially where distillation was involved. However, the high efficiencies and low pressure drops of these new packings have made large diameter towers a practical and economical mass transfer tool. We can cite distillation, absorption and even liquid-liquid extraction towers in successful operation whose diameters run 8 ft. or more.

☒ **Packed towers give higher pressure drops than tray columns.**

FALSE. Because of their low pressure drops, "Intalox" saddles and metal Pall Rings have found wide application in vacuum distillation. In these rather critical rectifications, metal Pall Rings, especially, have such low resistance that pot temperatures —and product pyrolysis—are maintained at a minimum. Moreover, these low pressure drop properties lead to smaller tower diameters with greater liquid irrigation densities and lower H.E.T.P.

☑ **Packed towers have lower first cost than tray towers.**

TRUE. Again, this is true because of the development in recent years of unique packing shapes. Their high capacity and greater mass transfer efficiencies permit the design of shorter and narrower columns, requiring smaller fluid moving equipment. Where corrosion is a factor, the low cost of chemically inert ceramic packings means impressive savings over the cost of special corrosion-resistant alloys.

☑ **Packed beds make efficient entrainment separators.**

TRUE. Mist elimination sections consisting of packed beds are used in commercial scrubbing equipment, even where the scrubbing sections themselves consist of trays. Moreover, the chemical engineering literature quotes many actual installations in sulphuric acid and other plants where satisfactory performance is being obtained from packed beds. Where fouling is a problem, the choice of the proper packing with a large interstitial free space, combined with adequate hydraulic radius, will prevent deposition of solids and thus maintain low pressure drop.

☒ **Performance of packed towers can't be predicted accurately.**

FALSE. Today packed tower performance can be predicted about as accurately as that of plate columns. That was not true, however, ten years ago. Accurate design data are multiplying rapidly as the use of packed columns continues to grow at a rapid pace. Extensive research being made in packed towers up to 30″ in diameter is providing data that can be used to predict the performance of towers up to 25′ or more with reasonable accuracy.

YES, *the introduction a few years ago of "Intalox" saddles, and, more recently, the metal Pall Ring, used with properly designed packed tower internals, has brought about a re-evaluation of methods used to effect mass transfer . . . have made yesterday's facts, today's fallacies. In new tower design, or to obtain greater capacity or better efficiency from present towers, it will pay you to investigate modern packed tower performance.*

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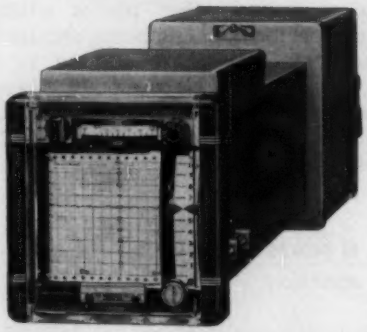

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Details of Stack Construction Draw Interesting Pros and Cons

To The Editor

In Frank L. Maker's article, "How to Specify Process Heaters" (August 1959 PETROLEUM REFINER) the last section, which pertained to stacks, contained several statements which are or could be misleading. I submit the following comments:

1. The definition of P_a includes the relationship, "(1 lb/ft^2 = 5.2 inches of water)". This should undoubtedly read "(5.2 lb/ft^2 = 1 inch of water)".

2. The definition of flue gas density (ρ) refers to "its" temperature. Does this imply average temperature, exit temperature, or furnace temperature?

3. It is difficult to understand why the author could make the statement that cylindrical sheet steel stacks are always cheapest. Depending on labor, material and transportation costs, concrete or even masonry stacks could be more economical. The example using a 180 x 9-foot stack may be valid, but does not prove that steel stacks are cheaper for all sizes since concrete stacks are not considered economical for heights less than 200 to 250 feet in most localities.

4. The author's statement that "for stacks up to 200 feet, the stack need be only ¼ to 5/16-inch thick", may be misleading since the thickness is dependent on diameter, total wind load and allowable buckling stress at the metal temperature. I am familiar with many stacks of 125 to 150 feet where greater thicknesses were required.

5. In spite of Mr. Maker's statement to the contrary, a conical flared section at the base of a self-supporting steel stack can be of considerable advantage in providing stability against overturning as well as aerodynamic stability. Frequency calculations may be lengthy, but are not impossible. A reasonably accurate approximation of the natural period of vibration of an unlined self-supporting steel stack with conical flare and constant plate thickness can be made by:

$$T = \frac{H^2_e}{3280D}$$

Where:

T = period, sec.
D = diameter of the cylindrical portion, feet.
H_e = height of an equivalent cylinder, feet; which for this case can be taken as the height of the cylindrical portion plus ½ of the height of the conical section.

For stacks of varying plate thickness or for a more accurate analysis, I refer the author to C. E. Freese's ASME Paper No. 58-PET-13, "Vibration of Vertical Pressure Vessels".

6. The author's reference to the use of "*plastic* insulation" on the outside of stacks is confusing when coupled with the operating temperatures of 600°F. The application of a castable insulation to the *inside* of the stack would not only prevent corrosion of the inside of the stack plate and prevent loss of capacity due to temperature drop of the gases, but would also reduce the metal temperatures considerably, thereby permitting the use of higher allowable stresses.

7. Wind loads as stated by the author appear to be slightly low as compared with the wind pressures (including the 0.6 factor for cylindrical surfaces) suggested for most areas by the ASA A58.1—1955 American Standard Building Code Requirements for Minimum Design Loads in Buildings and Other Structures. Assuming that the units of the wind velocity are mph rather than lb/ft^2 as shown in the article, the velocity of 129 mph does not seem to be consistant with the pressure of 15 lb/ft^2 on the projected area. Calculations made using the methods presented in the ASA A58.1 Code show that the velocity corresponding to the 15 lb/ft^2 wind pressure is approximately 96 mph.

8. The author states that the frequency of eddy formation is proportional to the *product* of the wind velocity and stack diameter. From ASME Paper 58-PET-13, from ASCE Transactions Vol. 121, and from other references:

$$f = \frac{VS}{D}$$

f = frequency of eddy formation
V = wind velocity
S = Strouhal's number
D = stack diameter

9. I also feel that the arguments presented by the author in favor of using guyed stacks rather than self-supporting stacks are not entirely valid. Self-supporting stacks are not only safer, but are also more economical in many instances. Guy wires and anchorages are frequently a nuisance and are susceptible to damage by fire or mobile materials handling equipment.

Leonard E. Olson

Whiting, Ind.

Author's Comments

I offer the following in reply to Mr. Olson's comments, using his paragraph numbers:

1. Mr. Olson is quite correct in noting that the relation should read "5.2 lb/ft^2 = 1 inch of water" instead of "1 lb/ft^2 = 5.2 inches of water." The equation is, however, correct as written, being expressed in lb/ft^2.

2. The density of flue gas is at "its temperature" in the stack. If there is no heat loss through the stack walls, this will be constant. If there is a temperature drop bottom to top, the average temperature should be taken.

3. In my experience, steel stacks have been cheaper than concrete. It is hard for me to conceive of a case where this would not be so, for the sizes and temperatures common in process stacks. I have had no occasion to design stacks higher than 200 feet. Mr. Olson's comment is not quite clear, but it would appear it applies to

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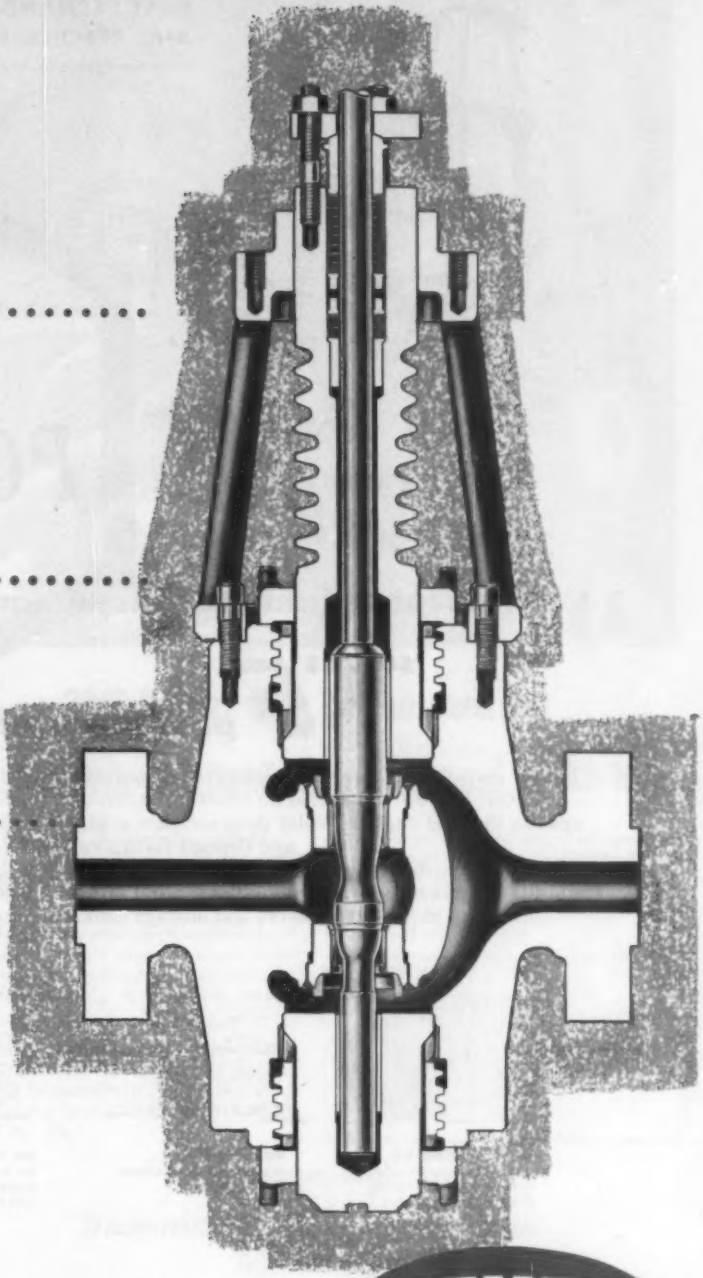

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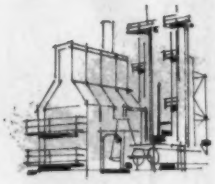

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concrete stacks over 200 or 250 feet high. For such cases, I would suggest comparison with alternative of a shorter stack with a fan, particularly as for large heaters there may already be a fan in connection with an air-preheater system. This is in the direction of power plant practice.

4. As to the thickness required for stacks, it is true, as Mr. Olson says, that the thickness depends on the diameter, total wind load, and allowable buckling load at the metal temperature (also on the height). In the length of the published article, it was not possible to go into complete details of stack designs. The paragraph was written because many of the published designs I have seen have been, in my opinion, unnecessarily thick, running to ½ inch or more. For the usual range of diameters, say 5 to 10 feet, and heights not over 200 feet, for process heaters with flue gas temperatures not over 600° to 700° F, I think my statement is essentially correct. For this range of temperature the ultimate strength of steel is not less than at atmospheric temperature, but may even be a maximum at about 600° F. This is of concern where the mode of failure is in bending. Where the diameter-thickness ratio is such that the mode of failure is by buckling on the compression side, the modulus of elasticity is the important criterion. This is about 20 percent less at 700° F than at atmospheric temperature. If the flue gas temperature is higher than 700° F and the quantity is appreciable, a question arises as to the economy of better heat recovery methods, such as air preheaters.

5. As to the advantages or not of a conical flared bottom on a stack, let us agree to disagree on this. To date I have found no difficulty with securing adequate anchorage of a straight cylinder to a foundation slab, to develop the required bending resistance. I think there is no question that the straight cylinder is cheaper. I suspect that the thought of securing better anchorage has been the real reason that flared sections were originally used, particularly in the days before welding construction simplified such matters, as the flared construction antedated modern methods of computation, including vibration effects.

As to the effect of the conical sections on the period of vibration, using Mr. Olson's formula and assuming the conical portion is one quarter of the total height, the stack with the conical bottoms will be stiffer than a straight cylinder of the diameter of the top and have a period about 23 percent less. This, in turn, means that the resonant wind velocity will be about 31 percent greater. Whether or not this is advantageous would depend on whether an increased resonant velocity would be thereby put in the region above the limit assumed probable.

6. The plastic insulation mentioned referred to the common mixture of asbestos fiber, diatomaceous earth and binding material commonly used for insulating other process equipment, and not to the castable mixtures containing fireclay that are used in furances. For the temperature mentioned of 600° F the latter has no advantage and is, I believe, more costly. If the insulation is placed inside the stack, the temperature of the steel may well be normally low enough to permit condensation of sulfurous and sulfuric acids from the flue gas from high sulfur fuels as this in-

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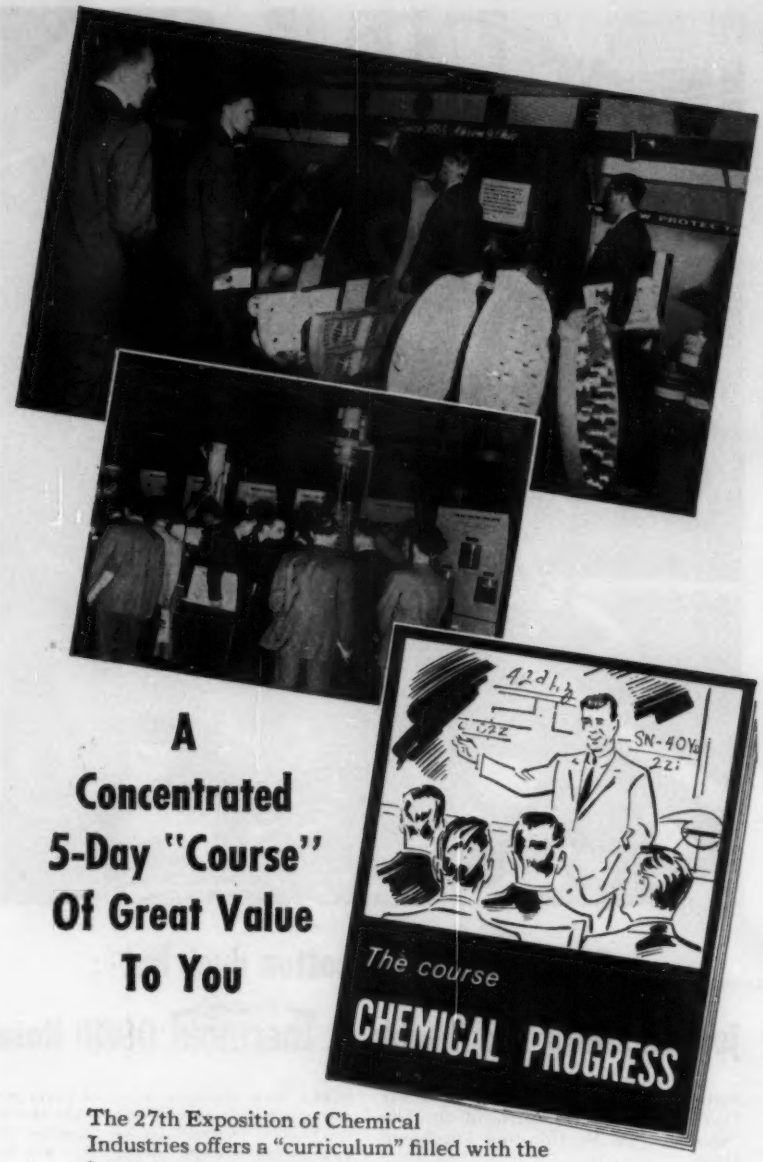

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sulation is porous and would be permeated with the flue gas. Such condensation can occur at temperatures as high as 300° F or 350° F with high sulfur fuels. The castable fireclay mixture would also be porous to some extent, and I would expect would be subject to cracks. This is the reason favoring placing the insulation outside, where the temperature is not so high as to appreciably reduce the strength of the steel, which 600° to 700° F is not.

I have also received a letter from D. G. Reynolds commenting on this same point, and mentioning a case we both knew about wherein, by an operational mischance, a large quantity of soot accumulated in the ducts and base of a stack and caught fire. This heated the bottom of the stack to incandescence and caused it to buckle. This stack was not insulated externally (and would not have performed differently if it had been) so Mr. Reynolds' coment could only apply to the desirability of insulating all stacks internally, regardless of the flue gas temperature. This is not common practice, and very probably not justifiable on the basis of the frequency of such accidents.

7. Mr. Olson suggests that my recommended wind loads are somewhat low and cites the ASA Building Code provisions. Here again space limitations resulted in too brief an exposition of the basis of my recommendations. (He also notes that in the second paragraph reference is made to a wind velocity of "129 lb/ft^2" which should obviously read "129 mph.")

The building code provisions include a factor of about 0.6 applied to the velocity pressure for cylinders, as compared with the drag coefficient of 0.35 used in my article. To justify my article, I quote from some of my unpublished lecture notes in more detail:

Lecture Notes: "For long cylinders this drag coefficient is a function of Reynolds Number. A chart showing the relation is given as Figure 57, p. 97 of 'Applied Hydro and Aero Mechanics,' Prandtl-Tietjens. This shows that for values of Reynolds Number in the range 1,000-400,000, the drag coefficient is fairly constant, with a value of 1.0 to 1.2, but that in the range above 400,000, the coefficient drops rapidly to a value of 0.35 at Re = 500,000 and continues at this value to higher values of Reynold's Number. For air at normal pressure, Reynolds Number for the cylinder may be taken as:

$$Re = 9{,}400\ VD$$

where V = wind velocity, mph
D = stack diameter, ft

For a stack diameter of 5 feet and a wind of 50 mph, this gives

$$Re = 2{,}350{,}000$$

"There is not (at the time these notes were written 10 or 12 years ago) a great deal of information on the value of the drag coefficient for values of Re greater than about 1 million, but from the nature of the flow and analogy with flow inside pipes, it would not be expected that the coefficient would rise until the velocity became so high that the stopping of the flow would increase the pressure and density appreciably with respect to atmospheric. This occurs at velocities approaching that of sound, which is in the order of 600 to 700 mph, depending on the temperature. (Mach number unity.)"

I would expect that there would be a

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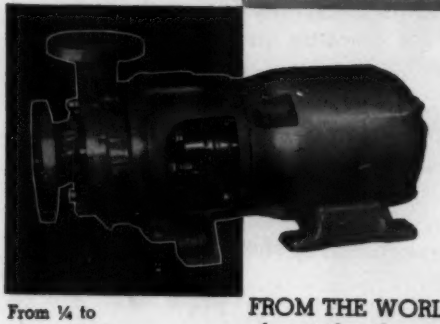

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great deal more data available now on the value of the drag coefficient as a function of Reynolds Number but have not had recent opportunity to look into this. I think it probable that the Building Code provisions (which are not available to me here now) do not include this refinement for high values of Re, and this accounts for the difference. For usual stack diameters and high winds, Reynolds Number, as indicated by the example, will be in the millions, and I would trust the aerodynamic data.

8. Mr. Olson is again correct in noting that the frequency of eddy formation is given by

$$f = \frac{VS}{D}$$

rather than proportional to the product VD. I must have been thinking of Reynolds Number when I wrote that.

9. Mr. Olson is not convinced by my arguments in favor of putting guys on stacks. Here again space limitations resulted in omitting considerable detail. I quote again from my lecture notes:

"The cheapest form of stack would be a thin steel cylinder guyed to prevent it being blown over by the wind. There are certain disadvantages to guys. These are: (A) They get in the way and interfere with traffic; (B) Interference of other structures may prevent locating the guys in the most effective places, which is to have three sets spaced 120 degrees; (C) Guys are subject to corrosion and require a certain amount of inspection and maintenance; (D) A guy may be destroyed in case of fire; and (E) A guy may also be destroyed if it is located so that a truck or other vehicle can run into it.

"For these reasons operators of equipment will generally object to guys and favor the so-called self-supporting stacks.

"However, these also have their disadvantages which include: (A) They must usually be designed thicker in the bottom sections to resist the bending moment; (B) The foundation must usually be very much larger and heavier to resist the bending moment. (Both of these make the self-supporting stack more expensive than a guyed stack) and (C) Self-supporting stacks tend to vibrate in the wind. Some proportions of stacks are so unfavorable that this may be the governing consideration."

There have been a considerable number of cases of difficulties with vibrations of self-supporting stacks, in some cases resulting in extensive cracks just short of total destruction. I have heard of no similar cases with guyed stacks.

I cannot, therefore agree with Mr. Olson that self-supporting stacks are safer, but rather believe to the contrary. However, to remove objections D and E to guyed stacks (that the guy may be destroyed) I currently recommend a compromise, as follows:

Design the foundation and anchorage to make the stack self-supporting for a wind load resulting at 60 mp, but provide guys for higher winds.

This will make a reasonable cost for the stack and foundation, but also secure safety if the guys should be destroyed under any conditions except very high winds. This assumes that a very high wind will not coincide with an accident to a

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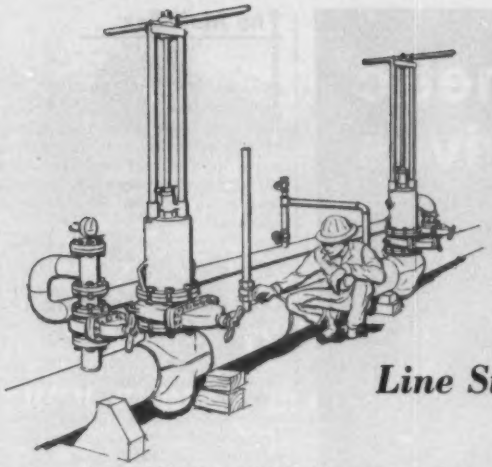

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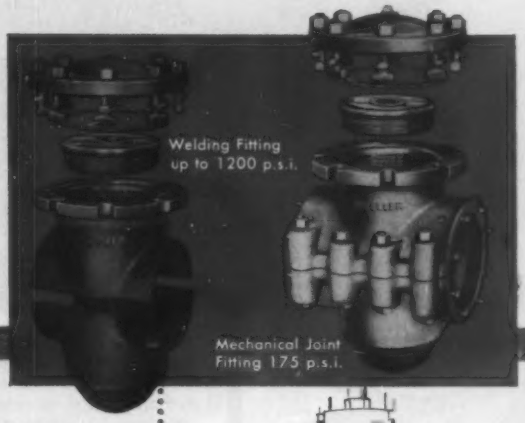
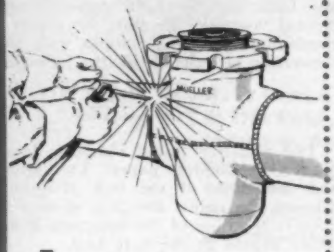
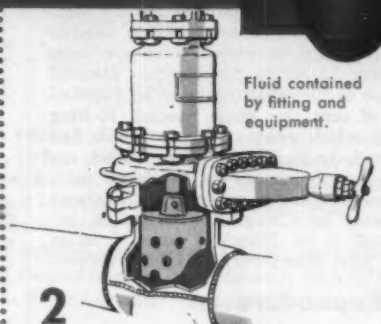


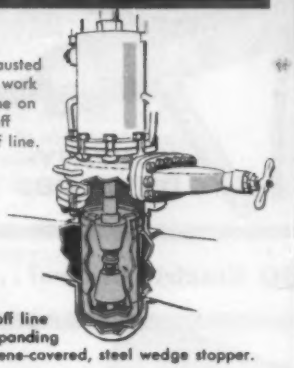


1 Weld fitting to line.



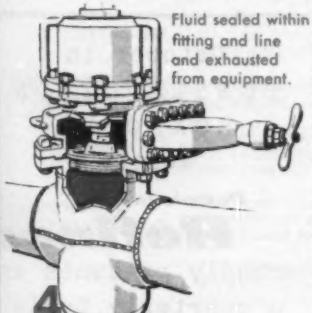
Fluid contained by fitting and equipment.

2 Cut out pipe inside of fitting to accommodate cylindrical stopper.



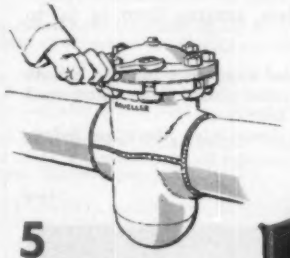
Fluid exhausted to permit work to be done on stopped-off portion of line.

3 Stop-off line by expanding neoprene-covered, steel wedge stopper.



Fluid sealed within fitting and line and exhausted from equipment.

4 Insert completion plug into top of fitting.



5 Bolt completion cap in place on fitting.

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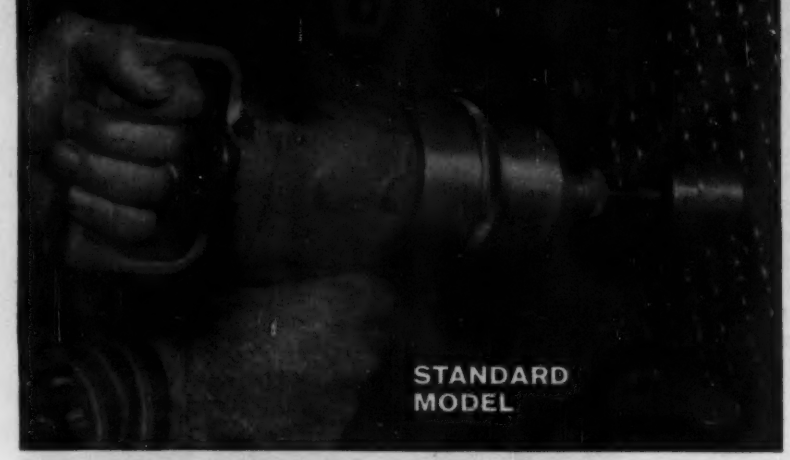

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guy, as being the product of two small probabilities.

It should be noted that the ovaling type of vibration is not affected by placing guys, and should be considered in all cases. This has been an important consideration in at least one case of extensive cracking.

Frank L. Maker

Questions Equation

To The Editor:

The article on estimating viscosity data by Dr. Huang and Dr. Johnson (May 1959 PETROLEUM REFINER) was a welcome addition to a most important field. Their review was good and their proposed equation for estimating the viscosity of liquids appears to be very useful. However, additional information on how they arrived at their Equation (16) would be helpful. Their equation apparently is not derived directly from the Licht and Stechert equation given in the paper, and I am sure that many readers would be interested in more detail.

Also, should not μ'_1 in the table of nomenclature be μ'_c?

Herman F. Reinhold, Jr.
Middleton, N. J.

Author's Comment

Thank you for your interest in our paper on viscosity. Your specific questions are answered as follows:

(1) Equation (16) was suggested by a combination of Thomas Equation (12), and Licht and Stecharts' equation on the critical viscosity. By this, we meant that combining the two equations with proper conversion of units, yields the following:

$$\mu = A \frac{\sqrt{M}}{T^{1/6}} \frac{(pc)^B}{(p^1)^{0.238}}$$

The available liquid viscosity data are plotted on log-log paper. The intercept and the slope of the best straight line through the points are used to obtain the numerical values of the constants A and B which should fit the data best.

The numerical values, 0.0172 and 0.87, were obtained and shown in the paper for the constants A and B respectively.

(2) The term (μ'_1) is a typographical error. It should be (μ'_c).

C. J. Huang

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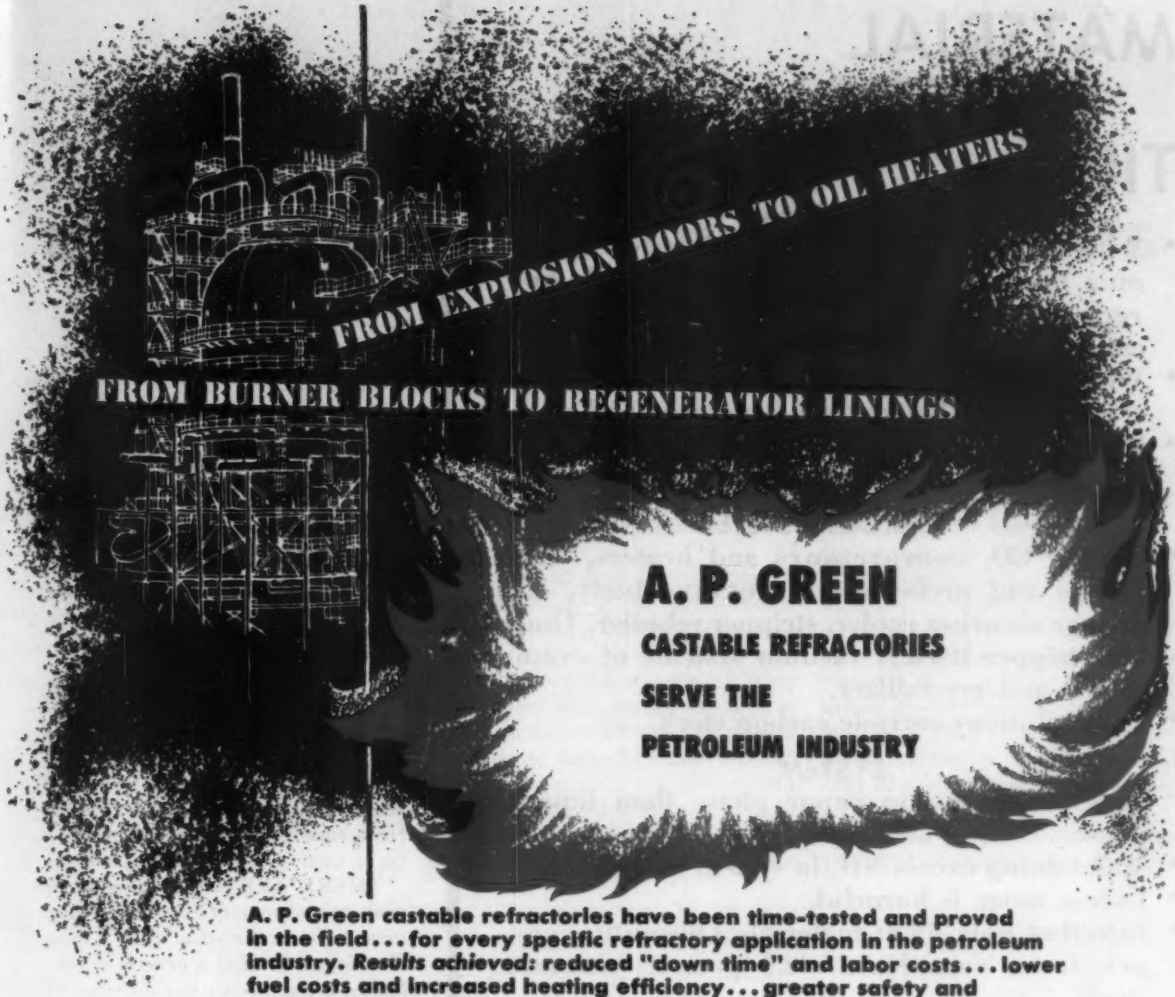

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- With oxygen present, stainless with 14 percent nickel is better than 8 percent nickel.
- 0.1 percent ammonium thiocynate inhibits corrosion in the autoclave.

CARBON STEEL

- Ok for CO_2 compressors and heaters, NH_3 pumps and preheaters, autoclave body, oil storage absorber cooler, stripper reboiler, (but not stripper itself), vacuum systems of evaporator and crystallizer.
- Urea solutions corrode carbon steel.

SYSTEM

- Less corrosion in vapor phase than liquid phase.
- Maintaining excess NH_3 in system is beneficial.
- Excess water is harmful.
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- Alloy N(40Ni-21Cr).

Materials

With accent on the Pechiney-Grace process, this article covers the performance of materials commonly used in urea synthesis plants

I. Wilenitz
Foster Wheeler Corp.
New York City

THERE ARE several processes now on the market for synthesizing urea from ammonia and carbon dioxide, all bearing a generic resemblance to each other but differing in important ways. All agree in carrying out synthesis at about 350° F and 2,500-3,000 psi. (In one or two processes, a somewhat higher pressure used.)

The stream leaving the synthesis autoclave consists of urea, water, ammonium carbamate and unreacted ammonia and carbon dioxide.

Most processes then proceed to flash this stream to a low pressure and heat it to break the carbamate down to more ammonia and carbon dioxide, while the aqueous urea, usually about 80 percent concentration, goes to a crystallizer or to evaporation and prilling.

In a "once through" process, the effluent ammonia and carbon dioxide would be utilized elsewhere, but if they are recycled in order to achieve higher conversion rates, it is from this point on that the family resemblance fades.

One process makes an aqueous solution of ammonium carbamate and

# of Construction for Urea Plants

pumps it back to the synthesis autoclave. Another absorbs the unreacted carbon dioxide from the mixture, liquefies the ammonia remaining and pumps that back to the autoclave. The absorbent is reactivated and the CO_2 discarded. A third scrubs the vapors with water to remove ammonia, which is then regenerated from the wash liquor and liquefied. The liquid ammonia and the carbon dioxide are returned to the synthesis autoclave by pumping and compressing respectively.

It will thus be seen that, generally speaking, most types of urea plant can expect to encounter corrosion problems which, although they may differ in degree, will resemble each other in kind.

This article, then, attempts to give a brief review of the performance of some materials of construction in plants synthesizing urea from ammonia and carbon dioxide, it being emphasized that the accent here is based on the Pechiney-Grace process as marketed today by Foster Wheeler Corp. in association with Grace Chemical Co. (See Figure 1). It is felt that a good deal of what is said will apply with some value to other processes, but it should be pointed out that the Pechiney-Grace process differs from its competitors by recycling unconverted ammonia and carbon dioxide in the following way. They are recombined into solid ammonium carbamate in a special reactor (the salt-oil-reactor) in the presence of a neutral oil. The resulting slurry is pumped back to the autoclave. The oil performs the additional function of carrying away the heat of the synthesis reaction.

Literature Study. A study of the published literature discloses little

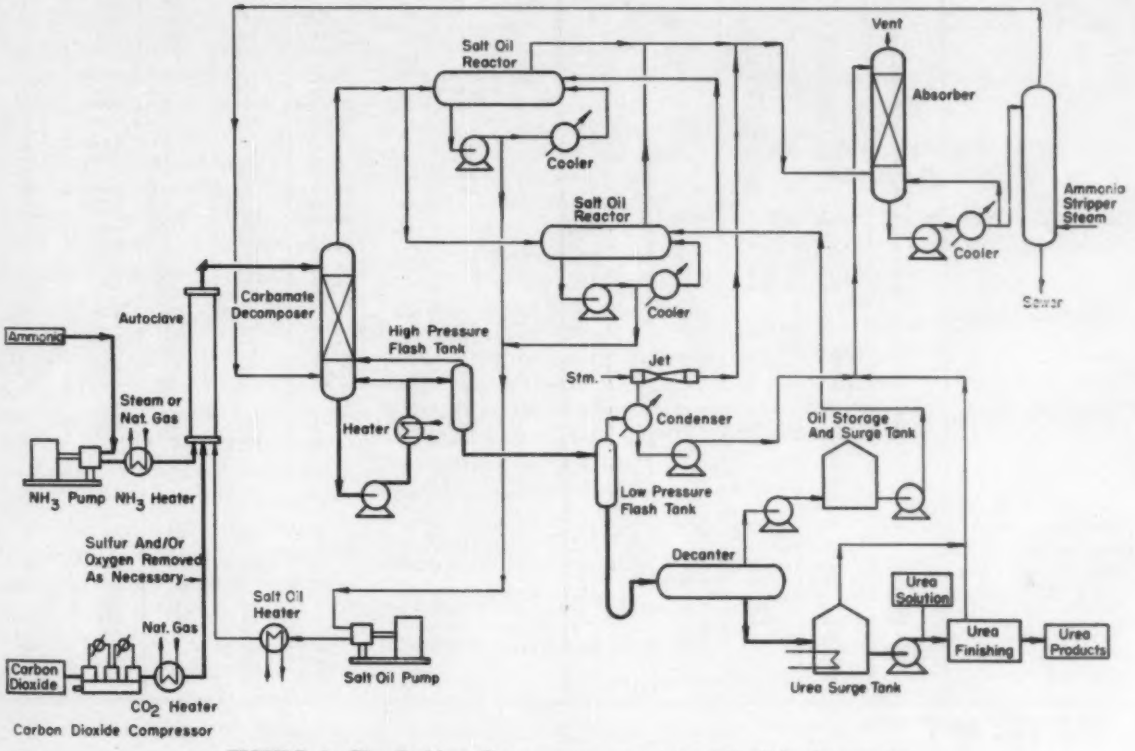


FIGURE 1—The Pechiney-Grace process uses a neutral oil in the reactor.

in the way of actual plant experience to go by. The Tennessee Valley Authority[1] has made an exhaustive literature survey and have drawn up a table of corrosion rates (Table 1) of various materials in chemical systems approximating urea autoclave conditions. Some of the data presented in the table, especially with respect to lead, is at least questionable to the writer's knowledge. Caution should be exercised in using the information, because for the most part, the data were derived from laboratory experiments rather than from actual plant experience. As an example, Thompson, Krase & Clark[8] packed a tin-lined jacketed laboratory autoclave with crystalline ammonium carbamate in which the corrosion specimens were suspended. The autoclave was heated by xylene vapor in the jacket for a number of days, after which some of the carbamate had decomposed to urea. While the method is ingenious, it cannot really be said to reproduce plant conditions exactly.

Apart from this, little of value is to be found in the published litera-

TABLE 1—Corrosion of Metals and Alloys in Urea Synthesis

MATERIAL Composition, Wt. Percent	Excess NH_3, %	Temp., °C.	Wt. Loss, g./sq. m./day	Penetration, in./year	Reference
Nonferrous Metals:					
Aluminum—Al	0	150	203	1.1	3
	0	165	443	2.4	4
	0	175	172	0.92	3
Al (Kolchugin)	0	175	146	0.78	3
	50	155	0	0	2
	50	175	173	0.92	2
	100	155	115	0.61	2
ASTM B209-48T—Al rest, Cu 3.5–4.5, Mn 0.4–1.0, Si 0.3–1.0, Mg 0.3–1.0	0	150	194	0.94	3
	0	175	96	0.47	3
	50	155	38.4	0.19	3
	50	175	60.0	0.29	2
	100	155	67.3	0.33	2
Chromium—Cr	0	142	0	0	8
	0	142	0.84	0.0017	8
	0	142	0	0	4
Aluminum Bronze—Cu 84.8, Al 11.6, Fe 3.2, Mn 0.7	0	175	3.6	0.0009	2
	0	175	7.93	0.015	2
	0	175	24.7	0.047	3
	0	175	32.7	0.063	2
	0	175	38.4	0.074	3
	0	175	40.8	0.078	2
	50	175	13.0	0.025	2
	100	155	0	0	2
	100	175	26.4	0.051	2
	100	175	14.4	0.028	2
Lead—Pb	0	142	1.1	0.0014	8
	0	150	0.1	0.012	6
	0	150	5.76	0.0073	6
	0	150	2.4	0.0030	3
	0	150	240	0.30	7
	0	150–65	150	0.19	9
	0	165	530	0.68	4
	0	175	24	0.030	3
	0	170–85	240	0.30	9
	50	155	28.8	0.037	2
	50	175	57.6	0.076	2
	100	155	31.2	0.040	2
	100	175	19.2	0.024	2
Nickel—Ni	0	142	1.5	0.0024	8
	0	150	20.0	0.032	7
	0	150–65	16.2	0.026	9
	0	150–65	23.1	0.037	9
	0	165	106	0.17	4
	0	175	108	0.17	3
Nickel-Copper—Ni, Cu	0	175	144	0.24	2
	0	175	72.8	0.12	3
Silver—Ag	0	142	0.26	0.00036	8
	0	150	0	0	3
	0	200	0	0	3
Tantalum—Ta	0	165	0	0	4
Tin—Sn	0	142	26.8	0.063	8
	0	165	4050	8.0	4
	50	155	20.4	0.040	2
	50	175	149	0.29	2
	100	155	113	0.22	2
	100	175	156	0.31	2
Zinc—Zn	0	165	Complete Solution		4
Ferrous Metals:					
Iron—Fe	0	150	200	0.48	6
	0	150	246	0.44	6
Electrolytic Iron	0	142	420	0.79	8
Steel—Fe	0	150	3000	5.5	7
Stainless Cast Iron—Fe, Cr	0	210	12	0.022	3
	50	155	16.8	0.031	2
	50	175	12	0.022	2
	100	155	2.4	0.0044	2
	100	175	0	0	2
E-Stainless 5—Fe rest, Cr 8–11, Si 2–3.5	0	150	141	0.26	3
	0	200	139	0.26	3
	50	155	39.6	0.073	3
	50	175	115	0.21	2
	100	155	12	0.022	2
	100	175	26.4	0.048	2
E-Stainless 4—Fe rest, Cr 8–14	0	150	341	0.63	3
Stainless—Fe 86.1, Cr 13.2, Mn 0.19, Si 0.50	0	150–65	2160	4.0	9
	0	150–65	2790	4.0	9
	0	165–70	3120	5.7	9
	0	185–200	2325	4.3	9
Vanadium Alloy—Fe rest, Cr 13.5, V 0.5	0	142	970	1.8	8
Chrome Iron—Fe rest, Cr 14, C 0.15	0	142	340	0.62	8
Chrome Iron—Fe rest, Cr 14.8, V 1.2, C 0.13	0	142	170	0.31	8
Chrome Iron—Fe rest, Cr 25.0, C 0.20	0	142	600	1.1	8
E-Stainless 6—	0	150	262	0.48	3
Fe rest, Cr 18–22, Ni 6.8	0	200	336	0.62	3
	50	155	223	0.41	3
	50	175	260	0.49	3
	100	155	130	0.24	3
	100	175	374	0.69	3
EI-183—Fe rest, Cr 17.9, Ni 9.45, Mo 4.36, Si 0.71, Mn 0.45, C 0.07, P 0.011	0	165	4.70	0.0098	5
	25	165	4.15	0.0076	5
	300 atm.[b]	165	3.93	0.0073	5
	600 atm.[b]	165	3.35	0.0061	5
CuO 0.06[a]	0	163	3.3	0.0070	5
CuO 0.125[a]	0	165	2.9	0.053	5
CuO 0.30[a]	0	165	0.72	0.0013	5
CuO 0.50[a]	0	165	0.26	0.00047	5
	300 atm.[b]	165	4.35	0.0080	5
	600 atm.[b]	165	4.68	0.0086	5
	0	200	14.2	0.026	5
	600 atm.[b]	200	9.3	0.017	5
CuO 0.5[a]	0	200	4.5	0.0083	5
CuO 0.3[a]	0	165	19.0	0.035	5
	0	165	6.7	0.012	5
V2A—Fe 71.4, Cr 19.3, Ni 6.7, C 0.319, Mn 0.3, Cu 0.2, Si 0.57, S 0.04, P 0.017	0	165–70	193	0.36	9
	0	200	259	0.48	3
	50	155	36	0.066	3
	50	175	177	0.33	3
	100	155	21.6	0.040	3
	100	175	57.6	0.11	3
V4A—Fe 71.29, Cr 19.13, Ni 6.4, Mo 1.7, Si 0.71, V 0.36, C, Cu, P	0	150	30	0.055	7
	0	165–70	30	0.055	9
V6A—Fe 68.9, Cr 20.3, Ni 7.05, Cu 2.78, Si 0.42, Mn 0.33, C 0.17, Mo, P, S	0	165–70	240	0.46	9
Ferromolybdate A111—Fe rest, Mo 5.75	0	142	570	1.0	8
Mybnickel S—Fe rest, Ni 31, Cr 17, C 0.15	0	142	17	0.031	8
E-Stainless 7—Fe rest, Ni 20–36, Cr 15–20, Si 2–3	0	150	55.1	0.10	3
	0	200	108	0.20	3
	50	155	53.5	0.093	3
	50	175	19.2	0.035	2
	100	155	12	0.022	2
	100	175	21.6	0.040	2

[a] Corrosion inhibitor in autoclave melt.
[b] Pressure of excess ammonia.

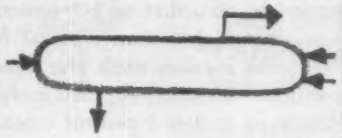
ture. The vendors of the various processes are in agreement only in that they claim to have solved all their corrosion problems, but are understandably reticent about the important details. If anything is said in public concerning materials of construction, it is usually restricted to a bare statement of the material used for the synthesis autoclave lining, e.g., silver-plated, lead-lined, stainless steel Type 316 lining or "undisclosed alloy."

However, the autoclave is not the only place in the system where corrosion problems are encountered. They are probably tougher there than elsewhere, but carbamate, wet carbon dioxide gas, etc., will also cause considerable grief.

Effect of Oxygen. Some general remarks can be made having universal validity. The presence of oxygen, and the quantities in which it is present, have a very important bearing on the corrosion resistance of metals. As a general rule, the presence of oxygen protects most of the common stainless steels. In fact, Stamicarbon N.V. (an offshoot of Dutch State Mines) has a patent[10] for protecting chromium-nickel steels by injecting into (or causing to be generated in) the synthesis autoclave a controlled quantity of oxygen. The steels are of the general composition 16-20 percent chromium, 10-14 percent nickel and 1.75-4 percent of either molybdenum or zirconium. The controlled oxygen concentration runs between 0.1 percent and 3.0 percent, based on the CO_2 feed rate. However, this patent gives an example of operation at about 340° F and it is believed that a really safe limit for these steels would be 330° F resulting in an enlarged autoclave. There is some reason to believe that the presence or absence of oxygen is relatively unimportant with stainless, once the protective film has formed. What matters is that the protective film should not be damaged but, if damaged, that there be oxygen present for repairing it.

Thus, with reducing agents absent (e.g., H_2S), the stainless steels, even with oxygen present, are not as good as lead, silver or aluminum bronze *with oxygen absent*. Stainless steels with 14 percent nickel are better than the usual 8 percent nickel content steels in the presence of oxygen, but are still not as good as the other metals mentioned, in its absence.

Excess CO_2. Another corrosive factor of great importance is the presence of an excess of CO_2 in the synthesis system. Experience has shown that preventing this phenomenon by maintaining an excess of NH_3 is beneficial. However, opinions differ on how much excess NH_3 is desirable. Quantities range from a few percent to several times the stoichiometric amount, although in the latter case there are important process reasons as well.



SALT OIL REACTOR

- **Use stainless steels and high alloy steels at temperatures below 275° F.**
- **Aluminum/silicon alloys perform well.**

Generally speaking, corrosion is much less in the vapor phase than in the liquid, and much stronger at the interface. However, if there is condensation on the exposed surfaces, and drainage back into the liquid, then corrosion is much greater on the exposed surfaces than in the liquid phase. DuPont has a patent[11] for using a copper-bearing solution to inhibit corrosion of certain stainless steels in urea service, in which they continuously wet the exposed metal surface.

THREE MATERIAL CLASSES

Various materials are discussed below under three broad headings: "Ferrous Metals & Alloys" (including nickel and chromium, for convenience), "Non-Ferrous Metals & Alloys" and "Non-Metals."

As is well known, most urea processes on the market are sold under license from European concerns. Much of the information on materials is based on compositions commercially available in Europe. These compositions, or ones resembling them, may or may not be readily available in the United States.

Important equipment items will be referred to continually, and for the sake of clarity, the following definitions are listed:

Autoclave: Urea synthesis autoclave.

Decomposer: Vessel for breaking down ammonium carbamate into NH_3 and CO_2 and driving off these vapors from the mixture of urea solution product and neutral oil.

Reactor: Where NH_3 and CO_2 are recombined into carbamate in the presence of oil, to form "Salt Oil" or carbamate-oil slurry.

Salt Oil Pumps: For circulating carbamate-oil slurry to the autoclave.

Salt Oil Heater: For preheating slurry before entering the autoclave.

Decanter: For separating oil from urea solution.

Absorber: For absorbing NH_3 from the unreacted gas mixture.

Stripper: For stripping NH_3 from its aqueous solution, formed in the absorber.

The urea solution is further processed by crystallization or by evaporation and prilling.

Terms such as "Evaporator Condenser" or "Decomposer Reboiler" are self-explanatory.

Ferrous Metals & Alloys

Carbon Steel. The Pechiney-Grace process circulates a neutral oil through the urea autoclave. There is consequently a decantation step required to separate oil from product urea solution after pressure has been let down and ammonium carbamate decomposed.

It has been found that the pres-

ence of corrosion products containing iron hinders the decantation by stabilizing any emulsion that is formed.

Carbon steel does not resist corrosion by urea solutions. This has been attributed to attack by ammonium carbonate which would be present because of hydrolysis of urea. Carbon steel cannot handle wet CO_2, but it can be used unprotected for oil storage, even though, in the latter case, traces of urea and carbonate might be present.

For technical grade urea, carbon steel is not even suitable for handling the bone dry material.

In the autoclave, the presence of ammonium thiocyanate in the amount of 0.1 percent by weight of the reaction mixture inhibits corrosion somewhat, but loss is still high.

Carbon steel may be used for the entire "front end" up to the autoclave, i.e., CO_2 compressors and heater and NH_3 pump and preheater. (Should the CO_2 be wet, however, some stainless steel will have to be used between compressor stages.)

The autoclave body, exclusive of the lining will, of course, be carbon steel. The metal has been found to be uniformly etched in the absorber, but without measurable loss. In the absorber cooler and stripper reboiler, carbon steel may be used with caution, but not in the stripper itself.

Finally in the vacuum systems of the evaporator and crystallizer, carbon steel may be used, again with caution.

Stainless & High Alloy Steels. A great deal of work was carried out in the thirties on the behavior of stainless and high alloy steels in the system urea-carbamate-water-ammonia-carbon dioxide. References 2, 3, 5, and 8 are only a few of the total listed in the TVA study.[1]

The main conclusions to be drawn from this early work are: (a) that excess ammonia is beneficial for these materials, (b) that nickel contents somewhat higher than is usual for 300 series stainless steels give better corrosion resistance, (c) that molybdenum up to 4 or 5 percent is beneficial, and (d) that excess water is harmful.

It is interesting to note that the inhibiting quality of copper compounds as stated by Hetherington and deRopp[11] is confirmed by a Russian experimenter, Krasil'shchikov,[12] who found that 0.3 percent of copper oxide in the reaction melt reduced the corrosion of EI-183 steel to one sixth of that shown in Table 1.

Incidentally, Hetherington also has a patent[13] for protecting chrome alloy steels against corrosion in urea synthesis melts, and also in later stages of urea manufacture, by introducing small amounts of polyvalent metals other than copper, e.g., bismuth, cobalt, iron, vanadium, etc.

The oxygen factor does not seem to have loomed large until a few years ago. The Stamicarbon patent on oxygen injection[10] quoted above is dated 1955.

As is well known, the Inventa process utilizes a specially developed alloy for the autoclave lining. A French patent of 1953[13] gives some indication of the compositions being considered by them, at that time. These compositions are given here together with the corrosion rates stated in the patent. The rates refer to surfaces 10 sq. cms. in area, but no temperature is given.

C %	Cr %	Ni %	Mo %	Cb %	Loss Mg/day	Ins./Yr. (Calculated)
0.1	16-19	14	2-3		0.67	0.00123
0.1	17-20	12-14	3-4		0.49	0.00090
0.1	16-22	7-13		10xC	0.39	0.00071

The losses indicated here appear to be fairly appreciable.

Some actual plant experience has been indicated in Table 2 for 304L, 316, and 317 stainless steel. It will be noted that these steels are entirely unsuitable for use in the autoclave, (since oxygen is absent) and, in the case of 304L, for the decomposer. In most other locations these materials are satisfactory.

Laboratory tests approximating autoclave conditions, but at 392° F, have been carried out for 10 days, with the results

TABLE 2—Corrosion of Three Stainless Steels in Various Parts of a Urea Plant, Inches Per Year

VESSEL	Reactor	Autoclave	Decomposer	
Phase	Vapor	Liquid	Base	Top
Length of Test	8 mos.	4 mos.	12 mos.	12 mos.
ALLOY				
304L	0.000006	Disappeared	0.020	0.004
316	0.000014	Disappeared	0.000010	0.000004
317	0.000013	0.08	0.000008	0.000004

TABLE 3—Corrosion of Alloy Steels in Synthesis Melt at Synthesis Pressure and 392° C

ALLOY	Loss in Inches/Yr.
SS 347	0.1407
SS 347 welded	0.1300
SS 316	0.1156
SS 316 welded	0.0840
SS 317	0.1052
SS 317 welded	0.1150
Alloy C20	0.0224
Alloy C20 welded	0.0549

The 316 exhibits an anomaly, with the welded specimen more resistant than the unwelded. This reversal should not be considered definitive.

TABLE 4—Corrosion of Nickel and Its Alloys in Various Parts of a Urea Plant, Inches Per Year

VESSEL	Reactor	Autoclave	Decomposer
Phase	Vapor	Liquid	Vapor
Length of Test	8 mos.	4 mos.	12 mos.
ALLOY			
Alloy N	0.00002	0.05	0.00003
Alloy J	0.00077	Disappeared	0 00009
ASTM B168-58T	0.00096	Disappeared	0.0007
Nickel	0.01450	.....	0.012
Monel	Disappeared	Disappeared	0.003
ASTM B333-58T	0.010	.....	0.007
ASTM B334-58T	0.0002	0.01	0.0006
Alloy F	0.00003	0.01	.....
Alloy M	0.0001	Disappeared	.....
Alloy H No. 25	0.00002	Disappeared	.....

listed in Table 3. The data confirm the theory that the materials listed are unsuitable for the autoclave, although certainly acceptable at low temperatures and pressures.

Other tests on a number of stainless steels of the 300 series have shown a small *increase* in weight of the specimen when exposed to decomposer conditions, in contradiction to the above. This was confirmed in two separate tests of 582 and 2000 hours duration. The increase was caused by an extremely adhesive brown organic film.

This apparent contradiction may lie in the simple fact that some stainless specimens may have been so thoroughly cleaned before testing that the passivating film has been destroyed and lack of oxygen has prevented its reforming.

Some plant upsets have caused decomposer temperatures to rise too high and if excess CO_2 is present, as is possible locally even with an overall excess of NH_3, attack will start and continue even when normal conditions have been re-established. The type of pitting corrosion seen on occasion has been typical of acid-vapor attack. Under these conditions, 304L is poor and 347 is attacked. Stainless 316, on the other hand, performs quite well.

Ammonium thiocyanate inhibits corrosion on stainless steels, as it does for carbon steel.

Stainless steel has been used in the salt-oil system where, of course, it has been exposed to erosive conditions. In this location there is an optimum slurry velocity above which erosion significantly shortens the life of stainless steels. In a laboratory test on 304 SS, using a slurry in oil of 40 percent by weight of ammonium carbamate, at a velocity of 13.5 feet per second, the steel lost material at the rate of about 1 percent of its weight per year. The samples were located in pipe bends, and the temperature was 149° F.

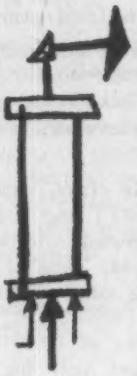
In summary, we would use the stainless and high alloy steels only at temperatures below 275° F, and we list the broad types below in descending order of resistivity (pointing out, again, that the Pechiney-Grace process excludes oxygen from the system):

1. Chrome 20% min. Nickel 10% min. eg. SS 309.
2. Chrome 18%, Nickel 8%, Mo 2%. Stabilized with Ti or N3.
3. Chrome 18%, Nickel 8%, Mo 2%. Not stabilized, eg. 316, 317.
4. Chrome 18%, Nickel 8%, extra-low carbon, eg. 304 L.

(Plain 304 would not be considered usable.)

Nickel and Its Alloys. There is little reference in the literature to the actual performance of nickel and nickel alloys in urea synthesis. Table 4 lists recorded corrosion rates in some units of an operating plant. Table 6 lists other experience obtained in the decomposer of another plant. In the latter case, the figures given are averages for two tests, 582 and 2,000 hours duration. To simplify reference, the nominal compositions of these nickel alloys is given in Table 5.

AUTOCLAVE



Satisfactory Materials

- Lead lining (99.99 percent pure)
- Type 316 stainless lining
- Aluminum bronze (no oxygen present)
- Silver plated gaskets
- Corrosion inhibitor—0.1 percent ammonium thiocyanate
- Body less lining—carbon steel
- Chromium carbide valves and spindles

Unsatisfactory Materials

- Type 304L, 316 and 317 stainless steels
- Nickel (no oxygen present)
- Monel
- ASTM B 168-58T
- Alloy N (40Ni-21Cr)
- Chromium alloys (with oxygen present)
- Aluminum
- ASTM B 209-58T (copper containing alloys)

TABLE 5—Nickel Alloy Compositions in Percent

ALLOY	Ni.	Cr.	Co.	Fe	Mo	W	Mn	Cu	C	Si	S
Alloy N[a]	40	21	....	31	3	....	0.6	1.75	0.05	0.4	....
Alloy J	34	21	....	45	....	....	0.85	0.5	0.05	0.4	0.005
ASTM B168-58T	77	15	....	7	....	....	0.25	0.2	0.08	0.25	0.007
Monel	67	....	....	1.4	....	....	1	30	0.15	0.1	0.01
ASTM B333-58T	Bal.	1	....	4-7	26-30	....	1	....	0.12	1	....
ASTM B334-58T	Bal.	15.5-17.5	....	4.5-7	16-18	3.75-4.75	1	....	0.15	1	0.03
Alloy F[b]	48	21-23	2.5	13.5-17	5.5-7.5	1	1-2	....	0.05	1	....
Alloy M[c]	19-21	20-22.5	18.5-21	Bal.	2.5-3.5	2-3	....	....	0.08-0.16	....	....
Alloy H No. 25	9-11	19-21	Bal.	3	....	14-16	1-2	....	0.05-0.15	1	....

[a] Plus titanium 10x Carbon.
[b] Plus traces of columbium and tantalum.
[c] Plus nitrogem 0.1-0.2 and (Cb + Ta) 0.75-1.25.

ASTM B168-58T (Type B) was an experimental variation of the ASTM B168-58T normal at that time, (1953), being somewhat higher in chromium. It is believed that present day ASTM B168-58T also runs a little higher in chromium than it used to.

TABLE 6—Corrosion of Nickel and Its Alloys in the Carbamate Decomposer

ALLOY	Inches Per Year
Nickel	0.0211
Nickel Welded	0.0203
Monel	0.0196
ASTM B168-58T	0.0011
ASTM B168-58T (Welded)	0.0060
ASTM B168-58T (Type B)	0.00127
ASTM B168 58T (Type B) (Welded)	0.00621

It will be seen that Table 6 gives higher values for nickel, ASTM B168-58T and monel than Table 5. In the case of monel, the rate is more than 6 times greater. It is difficult to correlate data on corrosion taken from two different plants at two different times. One cannot always know whether, and for how long, a plant may have been running under disturbed conditions. To treat the various materials individually:

Nickel. In the absence of oxygen and under autoclave conditions, nickel is strongly attacked. In the absence of oxygen and in urea solutions or urea-carbamate water solutions below 265° F, nickel is slightly attacked. In these solutions and at the same temperature, but with oxygen present, nickel is strongly attacked.

Monel. In the autoclave, monel is very bad, and is also considered unsuitable for use in the decomposer. It can be used to advantage in the stripper.

ASTM B168-58T. Also not to be used in the autoclave. This alloy may possibly be used in the stripper, but with caution.

Alloy N(40Ni-21Cr). This alloy has been tried under autoclave conditions for 10 days at 392° F. The unwelded sample showed a penetration of 0.192 inches per year, and the welded samples 0.0418 inches per year, which checks fairly well with the data in Table 4. This is not good enough for autoclave use.

Alloy H. Of this class, types C (ASTM B334-58T) and F have shown some resistance to autoclave conditions. Type C was tested under the same conditions as for alloy N(40Ni-21Cr) and gave penetrations of 0.013 and 0.0147 inches per year for the welded and unwelded specimens respectively. If restricted to 320° F, instead of the usual synthesis temperatures of 345-355° F, type C could possibly be used in the autoclave. However, it would result in a larger autoclave. These alloys have found important applications in the salt oil heater and salt oil pumps because of their resistance to erosion.

Alloy S. (Cr 28-30%, W 4-8%, Cl-1.35 percent balance Co). This high chrome alloy finds its usual uses of resisting wear in pump wearing rings and shaft sleeves. It cracked persistently in the salt oil pump valves even on the hardest of substrate metals.

Alloy C. (68-80% Ni, 17-19% Cr, 2-4% B, balance Fe and Si). Tensile strength 42,000 psi, Brinell Hardness No. 587. This material has been tried for salt oil pump plungers because of its hardness, but corroded badly in service.

Chromium and Its Alloys. Chromium itself, would theoretically be usable in the autoclave at temperatures above 265° F and *with oxygen present*. Unfortunately, its physical properties do not lend themselves to the manufacture of such a large item from the solid metal, and electroplating gives a covering that is too porous to protect the substrate metal. This holds true for the decomposer as well.

Chrome plating does, however, solve the salt oil pump plunger problem, and these are now giving excellent performance both here and in Europe, using base metals of steel or aluminum bronze with plated coatings ranging in thickness from 3 to 25 mils.

A process has recently been announced[14] for producing impervious layers of chromium by vapor-phase deposition. However, it remains to be seen exactly how resistant such a layer would be, and what is the largest piece of equipment that could be so treated.

The letdown valve on the autoclave is subject to an erosive mixture of carbamate, water, urea and gases. Chromium carbide valves and spindles have given good service here.

NON-FERROUS METAL AND ALLOYS

Aluminum & Its Alloys. Aluminum test pieces placed in the autoclave have completely disappeared in short order. As for carbon and stainless steel, ammonium thiocyanate inhibits corrosion somewhat, but not enough. For the rest of the urea plant, however, aluminum may be used wherever its mechanical properties allow and this would include piping. It is particularly favored by the absence of oxygen, but if below 275° F, it can even tolerate oxygen.

Alloys high in silicon and magnesium have proved themselves in operation, but those containing copper, eg. ASTM B209-58T should not be considered. The presence of iron in the aluminum is also undesirable.

Tests on Aluminum 3S samples in the decomposer, lasting 528 hours and 2,000 hours, have shown small increases in weight, of the same type as mentioned for stainless steels.

In Europe, a decomposer fabricated of 99.9 percent pure aluminum has given twenty years of trouble-free service, using aluminum raschig rings of the same metal. In another installation, the material used was an alloy AG 3 of greater strength than the pure aluminum. The composition follows, in percent:

	AG 3
Mg	2.5 - 3.7 (3 ave.)
Mn	0.2 - 0.5

Fe	0.4 max.
Si	0.3 max.
Cu	0.1 max.
Cr	—
Zu	—

Aluminum is susceptible to attack by mercury, which may be present accidentally from broken instruments. It would be wise to exclude instruments using mercury from aluminum equipment.

An erosion test, similar to that described for stainless 304 was carried out on half hard 3S aluminum using a 40 weight percent carbamate oil slurry at 13.5 fps. A test totalling 447 hours disclosed no loss in weight.

However, aluminum tubes have failed in salt oil heater service. One explanation offered is that aluminum alloys containing magnesium may precipitate Al_3Mg_2 at grain boundaries. This compound is anodic to the main body of alloy and could give rise to galvanic corrosion, especially if the component is under stress. Aluminum/silicon alloys have performed well in salt oil systems, but have never been tried in the decomposer. These alloys cast well and share the properties of aluminum in being satisfactory for most urea plant applications at temperatures below 265-275° F. A typical alloy of this kind is a French alloy, 12.2-13.7% Si, 0.7 Max. Fe.

Copper and Its Alloys. Copper itself has few applications in urea plants. Carbonated ammonia solutions do not attack it in the absence of oxygen because such attack is directly proportional to the concentration of oxygen.

Aluminum Bronze. One class of copper alloy, aluminum bronze, has been found to excel in many urea plants. Like its parent metal copper, it has poor resistance to ammonia compounds in the presence of oxygen, but excellent resistance up to 390° F when it is absent. Its use as liner material for the autoclave is hindered by problems of differential expansion, but it can be deposited satisfactorily on comparatively small surfaces by the gas-shielded arc welding method. Aluminum bronze is also used for components of the letdown valve which controls the outlet flow from the autoclave, and for some portions of the piping in the carbamate recycle system.

The first aluminum bronzes used in urea work had compositions 8-9 percent Al, 0.5-2.0 percent Mn, 0.2 maximum Fe and very few other components. Most U.S. bronzes of this nature, e.g., ASTM B169-55, run to more Fe and little or no Mn, giving an alloy that is somewhat more difficult to work and heat-treat.

Aluminum bronze is used for tubes in the salt oil heater, and great care must be taken first to heat treat the entire unit after fabrication, and second to insure that nozzles, etc., are aligned and bolted up correctly so as to avoid any residual stress. Resistance to corrosion is fine, even with NH_3 present both in the process and in the plant atmosphere, but this material is susceptible to stress corrosion.

Heat treating is carried out at 1150° F, for a period of one hour per inch of thickness of the material.

It is also advisable to design tubular units for shorter tubes, so that the tube vendor may crop the mill-run tubing more generously and avoid the more suspect material at each end.

Ammonia concentrations as low as 10 ppm have been held responsible for the failure of Al bronze, under stressed conditions.

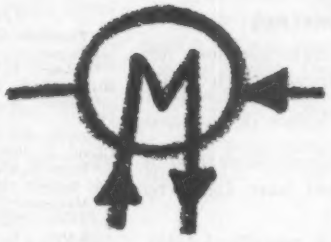
Finally, other Al bronze compositions have found their place in the salt oil pumps, e.g., cylinder liners, plunger base metal (chrome plated) and valve seats.

Incidentally, Al bronze, like aluminum, is rapidly attacked by mercury.

Lead. It is well known that Pechiney-Grace urea autoclaves are lead lined. Some statements have been made that the urea thus synthesized is "poisoned." Experience has shown that this is absolutely untrue.

The fact is that oxygen must be carefully excluded from the system. Deoxygenation is a well used and well understood process and presents

SALT OIL HEATER AND SALT OIL PUMP



- **ASTM 334-58T**
- **Alloy S (28-30 Cr, 4-8 W, 1.35 Cl, bal Co) good for pump wear rings and shaft sleeves. Do not use on pump valves**
- **Chromium plated pump plunger (base steel or al-bronze)**
- **Aluminum bronze heater tubes, pump cylinder liners, plunger base metal and valve seats**
- **Alloy N (40Ni-21Cr)**

no problem. In addition, it goes without saying that the lead lining must be installed with the most meticulous attention to manufacturing detail. The lead used should be of 99.99 percent purity. Less pure lead will possibly be satisfactory, but this is not a place to take chances.

Under the conditions described, there is no measurable loss of metal.

One advantage of circulating the neutral oil in the system is that it carries away the heat of reaction and prevents local points of overheating which might damage the lining. However, the lead in the autoclave must be protected from direct impingement by the incoming streams.

Lead lining would have a wider application in the rest of the plant if it were not for its comparatively high labor cost although machine methods of application are being studied.

Titanium. Titanium has been tested sporadically in various parts of the urea plant and has shown excellent corrosion resistance. It is still too expensive for general use.

About the Author

Israel Wilenitz is a project engineer for Foster Wheeler Corp., New York, where he is employed in the Contract Execution Dept. He has a chemical engineering diploma from Battersea Polytechnic, and a B.S. degree in mechanical engineering from Imperial College. Both of these institutions are schools of London University. Wilenitz has been a project engineer for Industrial Process Engineers, Newark, N. J.; senior mechanical engineer for Fertilizers & Chemicals Co., Haifa, Israel, and a chemical engineer for Petrocarbon, Ltd., Manchester, U.K.

Imperial Chemical Industries state that titanium samples exposed to carbonated ammonia liquor in an absorber bottom have shown 0.000008 inches per year penetration, where samples of 18-8 stainless containing titanium have shown 0.008 inches/yr.

Test pieces of titanium exposed in a decomposer have given 0.000006 inches/year at the top and 0.0005 inches/year at the vessel inlet.

More work needs to be done and is being done, but one suspects that until the price falls, the study is academic.

Tungsten. As for chromium[14] and molybdenum, vapor-phase deposition has indicated that impervious layers of tungsten are now possible, but further exploration is necessary.

Tungsten carbide has proved itself as valve and spindle material in the autoclave letdown valve, in which application it competes with chromium carbide. There is little to choose between them.

Others. Under autoclave conditions, at temperatures above 265° F and with oxygen present, platinum, gold and tantalum show excellent resistance. Needless to say, they are all prohibitive in cost, although tantalum might find application in certain crucial locations.

Silver is not perfectly resistant under these conditions until the oxygen concentration is zero. Under certain conditions it may be usable in the presence of oxygen. The main autoclave gaskets are silver plated but are not exposed directly to the reacting "malt."

NON-METALS

This class of materials does not appear to have found much application in urea plants.

Ceramic plungers have been tried in salt oil pumps and have failed by cracking.

An epon-base paint has been used to coat the interior of carbon steel oil storage tanks, where contamination by urea and carbamate is possible.

Glass lining has been considered for the decomposer but it is susceptible to thermal shock and to attack by alkaline atmospheres, not to mention simple mechanical damage.

Impervious Carbon and Graphite samples, with cemented bonds, have been tested, as follows:

Test 1—Molten 80% urea for 48 hrs.
Weight loss 0.02%.
No attack on cement.

Test 2—Molten 100% urea for 48 hrs.
Weight *gain* 0.05%, possibly by accumulation of biuret on rough surfaces.
No attack on cement.

Phenolic Resins. A modified phenolic with mica filler was used to cover steel corrosion specimens and tested for 96 hours in hot and cold urea solutions and in the presence of salt oil. It was considered to be resistant to those materials and usable. However, it would require further study, and would probably not be suitable for the autoclave.

Conclusion. The problems of corrosion in urea plants have not been simple. It would be fair to say that most of them have been solved, but that maintenance of urea plants is still somewhat more expensive than some other types of unit. The problems have been solved for the most part by comparatively minor changes to classes of materials already well known.

ACKNOWLEDGMENT

The author would like to acknowledge the assistance of W. W. Smiley, W. R. Grace and Co., Grace Chemical Div. and A. V. Slack, Tennessee Valley Authority, Wilson Dam, Ala., for their kind permission to publish certain material.

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Materials of Construction for Sub-Zero Temperature Service

Material behavior, relative costs, availability and mechanical design should all be considered when selecting materials for low temperature service

Milo Palmer
J. F. Pritchard and Company
Kansas City, Mo.

THERE HAS been a rapid expansion recently in the use of sub-zero service temperature processes. This, in turn, has brought about an urgent need to know about the behavior, relative costs, material availability and mechanical design and safe guards concerning the use of ferrous and non-ferrous materials in these services. It is, therefore, the purpose of this paper to present in general terms, some materials of construction, and to discuss the mechanical design of piping and equipment in rather broad terms.

Engineering tests on ferrous materials have provided information to show that, as the temperature of the material decreases from room temperature (except for those highly brittle materials) the hardness, yield, fatigue and tensile strength increases. It is also shown by test, that the ductility and the amount of energy absorption before fracture decreases. It is with these latter two properties that we are most interested in the selection of materials for construction for processes that operate at sub-zero service temperatures.

Materials for sub-zero service may be classified as to service temperature as shown in Table 1.

For any given material there are external and internal conditions which affect the embrittlement. The presence of surface blemishes and deep notches, and the simultaneous action of a high rate of straining, a non-uniform stress distribution, a tri-axial state of stress and low temperature are some of the external conditions affecting embrittlement. Some internal conditions affecting embrittlement are chemical inhomogeneities, discontinuities and cracks, grain size variations, structural inhomogeneities, residual stress, strain hardening or cold working and state of deoxidation.

The use of rimmed or semi-skilled steels should be used with caution in those conditions where shock loading may occur at room temperatures and below.

In Table 1 the division of temperatures and materials are arbitrary and could be changed, as the following discussion will show.

In most steel making processes the principal reaction is the combination of carbon and oxygen to form a gas. If the oxygen available for this reaction is not removed prior to or during casting (by the adoption of a deoxidizer) the gaseous products continue to evolve during solidification. If practically no gas is evolved the steel is termed killed. Increasing degrees of gas evolution results in semi-killed, capped or rimmed steels.

TABLE 1—Division of materials according to service temperature

Service Temperature	Material
0°F. to minus 20°F.....	Carbon Steel
Minus 20°F. to minus 50°F...	Carbon Steel Aluminum Killed
Minus 50°F. to minus 150°F..	Alloy Steel
Minus 150°F. to minus 320°F.	Alloy Steel or Non-Ferrous

Killed steels have a more uniform chemical composition compared to other types; there are however, some variations from surface to center and from top to bottom. Killed steel is a type in which there is only a slight evolution of gases during solidification of metal after pouring into moulds. De-oxidizing is usually done with silicon or aluminum. Alloy and stainless steels are always produced as killed steels.

Semi-Killed steels are characterized by variable degrees of uniformity and have properties intermediate between killed and rimmed steels.

Rimmed steels are characterized by marked differences in chemical composition across the section from top to bottom of the ingot. They have an outer rim that is lower in carbon, phosphorous and sulphur than the average composition of the whole ingot and an inner portion or core that is higher than the average in those elements. The typical structure of the rimmed steel ingot results from a marked evolution of gas during solidification of the outer rim. Satisfactorily rimmed steels do not retain any significant percentages of highly oxidizable elements such as aluminum, silicon or titanium.

From the above, it is understandable that rimmed steels show a very wide energy absorption at room temperature and because of this they should not be used in low temperature service. For shock loading they should be limited to probably 70° F, however, for non-shock or steady state loading they could be used for minus 20° F service. The semi-killed steels are improved over the rimmed steels and can be used

for service to minus 20° F without difficulty, except in severe shock service. The fully killed steels such as aluminum killed may be used to minus 50° F for average service such as vessels, pipe, valves, etc., but for severe shock even these should be limited to a higher temperature. For service temperatures below minus 50° F the use of nickel steels or non-ferrous materials should be used. The addition of nickel to the ferrous base will reduce the transition temperature; depending upon the amount of nickel. In Table 1, the division of minus 50° F to minus 150° F is for 3 to 3½ percent nickel steels. Depending upon the degree of control during manufacture, this steel will show Charpy Keyhole-Notch impact values as high as 20 to 25 foot-pounds at minus 265° F. An increase to 5 percent nickel for this same steel will show about the same results at minus 290° F.

The division of minus 150° F to minus 320° F usually results in the selection of the non-ferrous or austenitic stainless steels, such as type 304; however, the low carbon 8½ percent nickel steels, heat treated, will give 15 foot-pounds Charpy Keyhole-Notch tests at minus 320° F.

The cost, relative to plain carbon steel, is approximately as shown in Table 2. It must be remembered that in the purchase of the alloy or special steel, the quantity of the order greatly affects the price, and the table, therefore, may or may not be in error depending upon the quantity considered.

TABLE 2—Relative cost of pipe material

Material	A.S.T.M. Spec. No.	Cost of Pipe	Service Temp. °F.
Ferrous			
Carbon Steel			
Plain	A53 Gr. A	1.00	— 20
Killed (Alum.)	A106 Gr. A	1.10	— 40
Killed	A333 Gr. C	1.91	— 50
Alloy Steel			
Ferritic Type			
3½% Ni.	A333 Gr. 3	3.33	—150
5% Ni.	A333 Gr. 5	3.92	—150
8½% Ni.	To A333	5.83	—320
Austenitic Type			
18% Chrom 8% Ni.	A312-TP304	8.76	—320
18% Chrom 8% Ni.	A312-TP316	14.06	—320
18% Chrom 8% Ni.	A312-TP321	10.10	—320
18% Chrom 8% Ni.	A312-TP347	12.81	—320
25% Chrom 12% Ni.	A312-TP309	12.05	—320
25% Chrom 20% Ni.	A312-TP310	17.09	—320
Non-Ferrous			
Brass	.....	4.47	—320
Copper	.....	4.59	—320
Aluminum	6061-T6	1.47	—320
Aluminum	3003	1.28	—320

Piping. The design of piping for sub-zero service does not differ greatly from that at elevated temperatures. The calculations for flexibility are made in the same manner, however, one must remember that the movements are contractions and not expansions. Therefore, on the examination of the piping for flexibility must be more thorough for sub-zero temperatures than for elevated temperatures.

The following is a list of some of the many things to examine critically in any piping system.

- Direction of movements
- Method of supporting
- Flange bolting
- Gasketing material
- Branch connections
- Temperature gradient
- Dis-similar materials
- Tri-axial stresses
- Re-entrant welds
- Valves: (a) Extended bonnet
  (b) Packing
  (c) Pressure relief for entrapped fluid.

The direction of movement of the piping as stated above is critical and must be examined closely. These contractions will also effect the method of supporting and anchoring the piping. The supports or hangers should be placed such that there will be a minimum of heat gain by the fluid in the pipe, this usually means hard maple wood blocks between the pipe support shoe and the steel or concrete support.

For pipe hangers, the pipe attachment should extend past the insulation a sufficient distance such that ice formation will not effect the operation of the hanger. The maintenance of the insulation seal around a piercing support or hanger is a rather difficult job to perform, as the formation of ice on the piercing member tends to break the seal. This problem can be lessened somewhat by insulating the piercing member for a distance from the pipe insulation of about twice the pipe insulation thickness. The flange bolting will not be too great a problem so long as the contraction of the bolting and flange is similar. If possible, the bolting should be of the same or similar material as that of the flanges. The gasket material can vary quite widely, depending upon the service temperature and upon the fluid flowing.

Gaskets may be compressed asbestos, metal, metal jacketed or spiral wound retained. The compressed or sheet asbestos gaskets tend to become brittle at low temperatures and because of this, the writer does not use them for service temperatures below minus 20° F. Metal gaskets, and spiral wound gaskets may be used for temperatures to minus 320° F, depending upon the materials. Aluminum, copper or austenitic stainless steel gaskets are all serviceable to minus 320° F. Plastic gaskets of the fluorocarbons have been recommended for use at temperatures as low as minus 260° F. However, the writer has seen no data to show that these materials do not become brittle at this low temperature.

On piping, there is a tendency to change materials (on small branch connections) to main headers; this should be examined closely for corrosion due to dis-similar metals. This is true also for gasketing and bolting materials.

Welding of ferrous materials for sub-zero service is one in which the notched-bar behavior is complex due to such factors as:

- Dissolved gases
- Variations in base metal and weld metal
- Heat affected zone
- Re-entrant welds

• The dissolved gases may be minimized by using low hydrogen, coated electrodes or submerged arc welding.

• The use of electrodes of a material that is not compatible with the base metal may set up stresses due to the difference in expansion of the two materials, especially on thick walled materials.

• The welding of ferritic base materials with austenitic electrodes may result in a brittle structure of the fusion zone because of dilution of the austenite weld metal. Some relief from this condition may be found by using type 310 electrodes.

• Under-cutting and sharp edges are to be avoided for all low temperature service.

• Anneal, where possible, for grain refinement.

Pressure Vessels. The A.S.M.E. Code, Section VIII, Unfired Pressure Vessels, covers the design and construction for pressure vessels for temperatures down to minus 20° F and more specifically, by paragraph UCS-65, 66, 67 and UHA-51 for temperatures below minus 20° F.

It will be noted that paragraph UCS-66-d lists certain exemptions to the requirements for impact tests, of which one is that "no impact tests are required on any material for use at temperatures of minus 20° F and above, or for use below that temperature when due to a lower seasonal atmospheric temperature." The above statement is, in the opinion of the author, too broad a statement. For severe shock loadings even at room temperatures, the rimmed steels show very erratic Charpy impact tests and obviously should not be used at sub-zero service temperature.

Part UNF-65 exempts non-ferrous materials from impact tests down to minus 325° F.

Part UHA-107 cautions against the use of dis-similar weld metals when welding ferritic type stainless steels with austenitic type electrodes.

It would be well to exercise caution in stamping material for use in severe shock service at very low sub-zero temperature service because of the localized stress pattern that would be induced in the stamped material.

Valves. Block valves should have extended bonnets for service in which the fluid temperature is approximately minus 75° F and lower. Valve stem packing for the extended bonnet valves is not too much of a problem due to the packing gland being outside the insulation. Generally, the under or pressure side of the gland is blanketed with vapor at a temperature higher than the temperature of the fluid in the line.

Safety protection must be provided on those lines handling highly volatile fluids such as methane, ethane, oxygen, hydrogen, etc., to provide for the vaporization of the fluid due to heat leak on a blocked-in line. The capacity of valve required may be readily calculated from the heat leak through the insulation. Trapped pockets of the cold fluid, such as in the bonnet of gate valves, plug valves, etc., must be provided with some means of relief against a build-up in pressure which may rupture the container if allowed to rise too high.

Insulation for sub-zero service may be of several different materials and types depending upon the intended service temperature, however, for extremely low temperatures the field narrows to vegetable cork, mineral wool, perlite, cellular glass, balsa wood and vacuum type. The perlite, most generally used for double shell tank insulation, has a density of 3.0 to 4.0 pounds/cubic feet and is poured or blown into the cavity. Table 3 gives some of the properties of the above insulations.

TABLE 3—Properties of low temperature insulation material

Material	Coefficient of Conduction Btu/Hr./Sq. Ft./°F./In. 0°	−100°	−200°	Coefficient of Linear Change with Temperature In./°F.
Balsa Wood	0.33	.....	.....	.....
Cellular Glass	0.35	0.29*	0.23*	4.6×10^{-6}
Mineral Wool	0.25	0.21*	0.16*	2.0×10^{-6}
Vegetable Cork	0.24	0.21*	0.17*	5.0×10^{-6}
Perlite (3.5 #/Cu. Ft.)	0.18	.....	....	.....

* Values obtained by extending conductance curve.

General. The classification of materials as to the minimum service temperature in which they should be used depends upon whether the material will be subjected to shock loading or upon a steady static load. If the load is a steady static load, it is obvious that plain carbon steel would withstand extremely low temperatures. This condition, however, rarely exists in process plants. In piping and equipment it is normal to obtain various degrees of shock; even the steady flow of fluid in a pipe will produce vibration which depending upon its velocity will vary from slight to severe vibrations. It is, therefore, important to select materials for sub-zero services which will withstand the shock expected at the service temperature.

Some of the non-ferrous materials used for sub-zero temperatures will not withstand very much heat and in case of fire may rupture rather quickly. This safety consideration may result in using the ferrous steels.

In the construction of equipment, it is quite common to use different materials to conserve on the more expensive materials of the piece of equipment. The expansion or contraction of these differing materials should be examined closely to make sure that the equipment will not bind rotating parts or warp the piece of equipment to such extent as to make it unserviceable or unsafe.

Of the many methods for measuring the low temperature embrittlement of ferrous materials, the Charpy Keyhole-Notch method is probably the best known as it is primarily applicable to the classes of steels of low hardness and low notched bar impact resistance such as hot rolled or normalized carbon and low alloy steels, and permits discrimination between the more and less brittle steels of the above types at room temperatures and below.

Generally for sub-zero service temperatures a minimum value of 15 foot-pounds Charpy Keyhole-Notch specimen tests are specified for the material at the operating temperature. For some conditions of shock loading it would be desirable to increase the minimum energy from 15 foot-pounds to 20 foot-pounds or more depending upon the severity of the shock.

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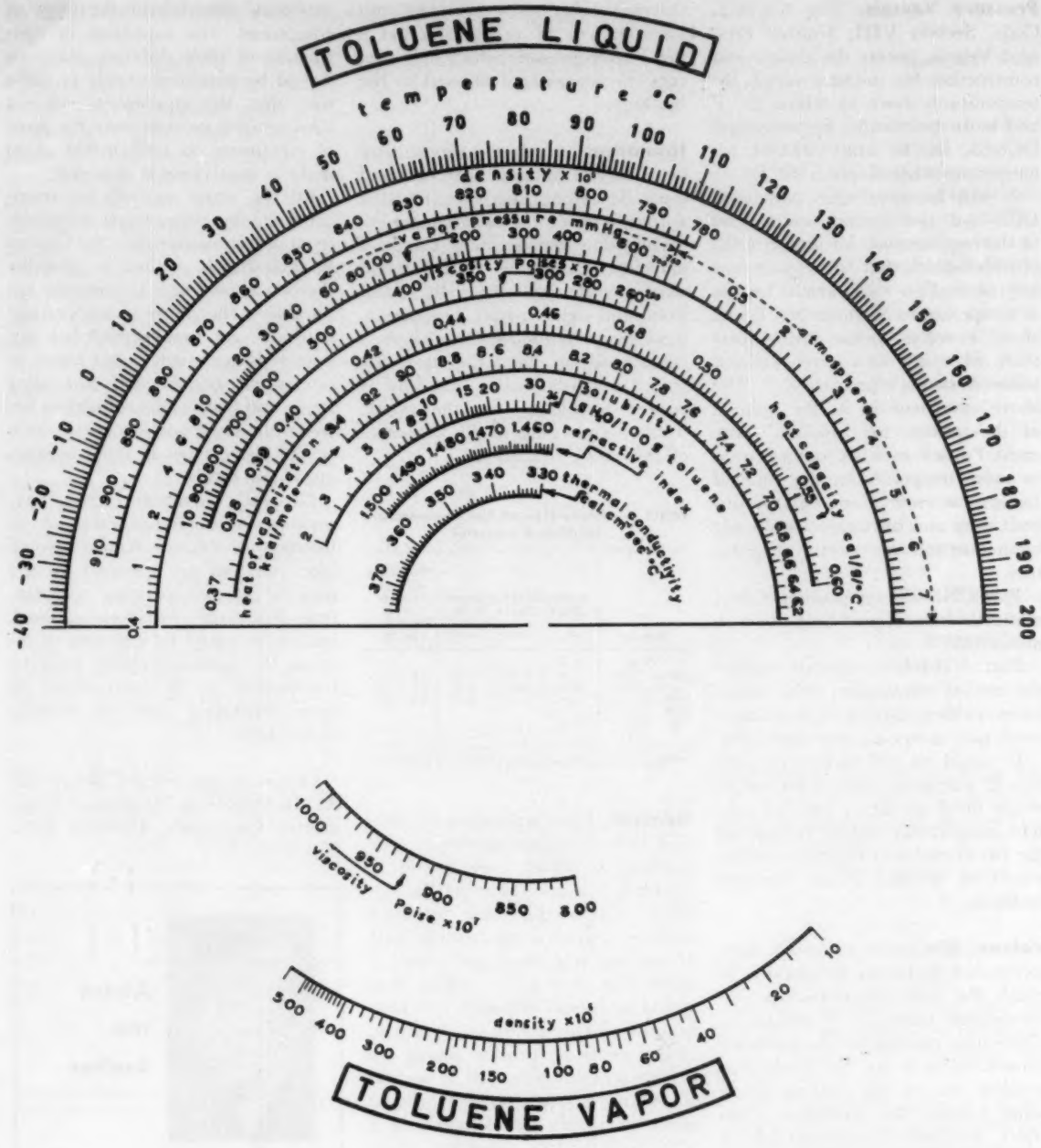
About the Author

Milo Palmer is chief design engineer for J. F. Pritchard & Co., Kansas City, Mo., where he is in charge of a design section covering mechanical, structural, electrical instruments and pressure vessel design. Holder of a B.S. degree in mechanical engineering from the University of Illinois, he has 25 years of engineering experience in the refining industry. With Pritchard for 11 years, he has also been with Standard Oil Co. (N.J.), Standard Oil Co. (Indiana), Shell Oil Co., Huasteca Petroleum Co., and Lago Oil & Transport Co.



Find Toluene Properties by Nomogram

A. M. P. Tans
Staatsmijnen in Limburg, Geleen, Netherlands

THIS NOMOGRAM,[1] giving the physical properties of toluene, has been constructed from literature values.

The use of circular scales has the advantage that in any position of the nomogram is read perpendicular to the scale, and, that within a given space a circular line can be longer than a straight one.

The use of the nomogram is as follows: Any line passing through the center intersects the scales in corresponding points; the temperature scale should be used both for the liquid and for the vapor.

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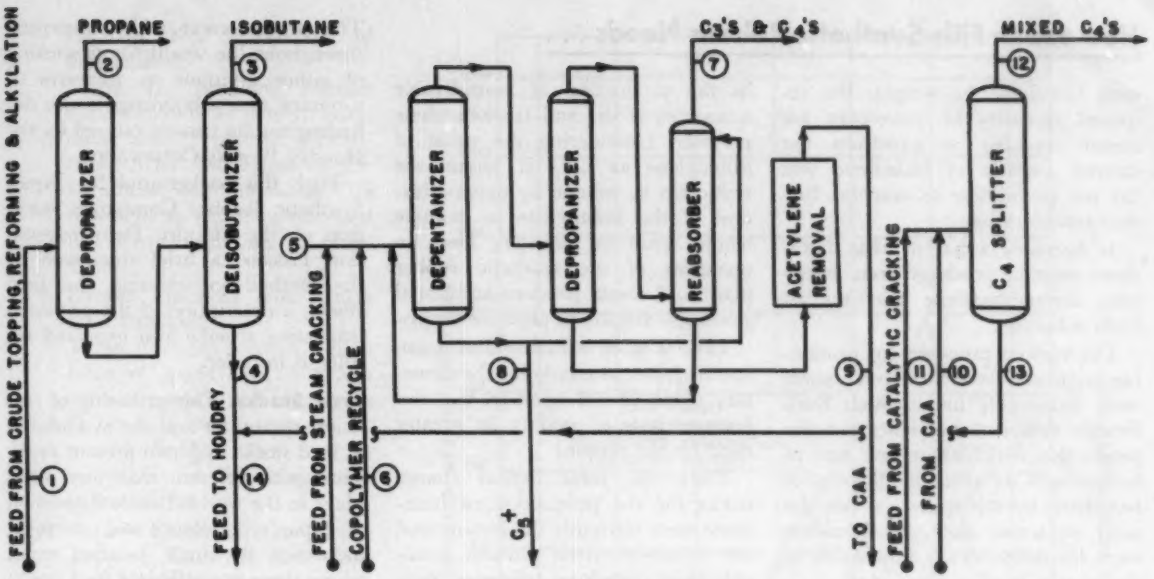

FIGURE 1—This was the most economical feed preparation scheme for making butadiene charge stock in Japan.

How Japan Fills Synthetic Rubber Needs

By carefully gathering available petroleum raw materials and selective processing, Japan will have an economical synthetic rubber program

K. Kawasaki, Japan Synthetic Rubber Co., Tokyo
H. D. Noll and A. K. Logwinuk, Houdry Process Corp., Philadelphia

DESPITE JAPAN'S proximity to the major natural rubber producing countries, there are many economical and practical reasons why it is highly desirable to install facilities for producing synthetic cold rubber (SBR) and decrease imports of natural rubber to Japan.

Why Synthetic Rubber. The primary considerations for the production of SBR are summarized as follows:

1. Reduction in foreign currency outlay.

2. Creation of additional Japanese industry.

3. Possibility of producing new and improved formulations.

4. Stabilization in over-all costs of rubber materials to Japanese consumers.

5. Improvement of Japan's petrochemical position in the world.

6. Exploration of synthetic-natural rubber compounds.

Since the major ingredient of SBR is butadiene, it is obvious that the economics of producing SBR are contingent upon the selection of an economical means of producing butadiene.

Which Butadiene Process? Many methods are available for the production of butadiene, including the following commercial methods:

1. Production from acetylene by:
   a. Conversion to acetaldehyde to acetaldol, then to butylene glycol and finally to butadiene.
   b. Conversion to acetaldehyde then to ethyl alcohol and to butadiene.

2. Hydration of ethylene to ethyl alcohol, then to butadiene.

3. Ethyl alcohol to butadiene.

4. Steam cracking of petroleum fractions for butadiene, butylenes, propylene and ethylene.

5. Dehydrogenation of butylene to butadiene.

6. Dehydrogenation of butane to butylene then to butadiene.

7. Single-step dehydrogenation of butane to butadiene.

The processes involving acetylene, ethylene or ethyl alcohol for butadiene production do not warrant consideration in Japan, since the basic materials are too costly.

Thus, it became obvious during the initial planning for JSRC's rubber plant that the most logical means for producing butadiene would be from petroleum.

With the expanding petroleum industry of Japan willing to cooperate, it became necessary to investigate the available processes in order to ascertain the most economical method for conversion of the petroleum by-products to butadiene.

At first, steam cracking indicated some promise. However, since this method produces only 2.5 to 3 per-

cent butadiene by weight, the required quantity of petroleum for steam cracking to produce the desired amount of butadiene was far too prohibitive to warrant further consideration.

It becomes apparent that butadiene must be produced from butylenes, butane-butylene mixtures, or from *n*-butane.

The various processes for producing butadiene from these compounds were thoroughly investigated. Even though sufficient butylenes for the production of 27,500 metric tons of butadiene were available, the cost of butadiene by this route was not the most attractive since the butylenes were not economically procurable in the required volume in Japan.

Minimize By-products. The Japan Synthetic Rubber Company's prime object was to produce butadiene with a minimum of by-products. If butane-butylene mixtures, which normally contain considerable quantities of isobutane and isobutylene, were to be the initial materials, it would be necessary to resort to an expensive step for the removal of the isobutylene in order to retain the butylene-1 as a butadiene former.

This removal step would result in the production of considerable quantities of di- and tri-isobutylene polymer. Considering the value of isobutylene as LPG is Japan, the reduction in volume by polymerization of the isobutylene to gasoline would result in monetary losses to operators of the synthetic rubber plant and would produce additional gasoline—already in plentiful supply.

LPG is more valuable than gasoline in Japan, not only for the monetary value placed upon it, but also because it is a product in greater need by the people.

Thus, the most logical charge stocks for the production of butadiene were obviously the butane and the butane-butylene streams available from petroleum refineries. Supplementary feed stocks could be the by-product butane-butylene fractions available from steam cracking of petroleum fractions for ethylene production. These by-product butane-butylene fractions contain 30-40 percent butadiene.

It is possible to prepare feed stocks for dehydrogenation of butane-butylenes to butadiene by simple fractionation of the refinery fractions and the butane-butylenes from steam cracking, but only after buatdiene extraction from the latter.

The process most widely accepted throughout the world for processing of either *n*-butane or mixtures of *n*-butane and *n*-butylenes is the dehydrogenation process offered by the Houdry Process Corporation.

With this background for Japan Synthetic Rubber Company's selection of the Houdry Dehydrogenation Process, a brief discussion of the method in selecting the feed stocks, a description of the proposed processing scheme and expected results, is in order.

Feed Stocks. The gathering of sufficient quantities and the availability of feed stocks in Japan present problems quite different than any other place in the world. Due to dispersion of Japan's petroleum and chemical industries, no single location exists where there are sufficient feed stocks available to produce the desired quantity of rubber. As a result, in order to minimize transportation and feed stock costs, it became necessary to select a location near the greatest source of the most desirable feed stocks.

The selection of feed stocks was based upon the greatest production of butadiene per unit of charge. The order of preference in feed stock selection was as follows:

1. **Butane-Butylene Byproduct Fractions from Steam Crack-**

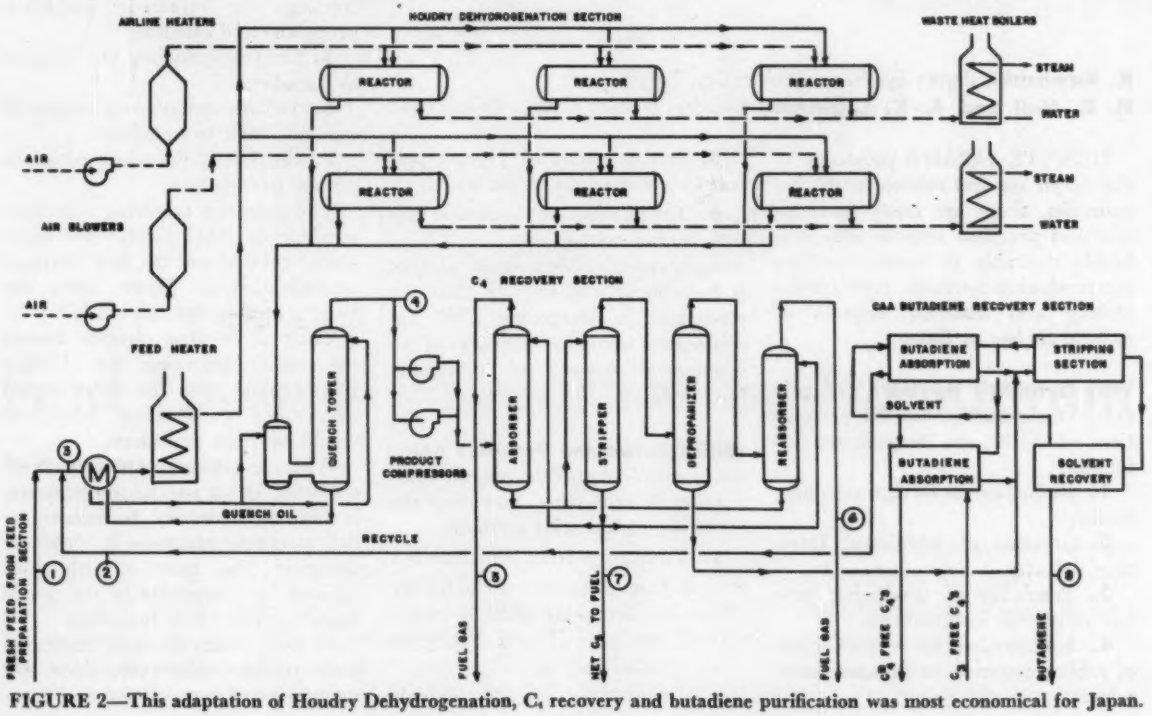

FIGURE 2—This adaptation of Houdry Dehydrogenation, C_4 recovery and butadiene purification was most economical for Japan.

ing for the Production of Ethylene
These C_4 fractions contain approximately 38 percent butadiene and 32 percent *n*-butylenes. After extraction of the butadiene, the remaining C_4's represent an excellent raw feed for dehydrogenation to butadiene.

2. **Butane Fractions from Catalytic Cracking**
These fractions contain a high ratio of *n*-butylene, but also contain considerable quantities of *iso* C_4's which must be removed before the feed is acceptable for dehydrogenation to butadiene.
3. **Butane Fractions from Crude Topping, Catalytic Reforming and Alkylation Plants**
These fractions are mixtures of isobutane and *n*-butane and require deisobutanization since only *n*-butane is directly convertible to butadiene.

Feed Preparation. This variety of feed stocks presented a problem in the selection of the most suitable means for preparing the charge stock to the Houdry Dehydrogenation plant. Important considerations were:

1. Removal of *iso* C_4's with minimum loss of butylene-1 and other butadiene formers.
2. Economics involved in feed preparation.

Various schemes were process engineered and their economics studied. After numerous consultations between engineers from Japan and the United States, the processing scheme shown in Figure 1 was selected as being the most flexible and economical in first cost, in operating costs, and in the cost of finished butadiene.

The C_4 stream from steam cracking, together with recycle from the copolymer plant, is fed to a deoiler where pentane and heavier components are rejected as a liquid which may be utilized as fuel. Overhead from the deoiler which contains mixed C_4's including butadiene and mixed C_3's is then depropanized in a separate column. The bottoms from the depropanizer are then passed through an absorption section of the CAA unit (Flow Illustrated in Figure 2).

The unabsorbed material, consisting of mixed C_4's from catalytic cracking are passed to a splitter column, Figure 1. The splitter column is a precise fractionation column, designed to split out the *iso* C_4 compounds with a minimum carryover in the overhead of butadiene formers other than butylene-1 which boils in same range as isobutylene. Hence, the overhead consists predominantly of isobutane, isobutylene, and butylene-1, whereas the bottoms, which constitutes a portion of the fresh feed to the Houdry dehydrogenation unit, is mainly butylene-2 and butane.

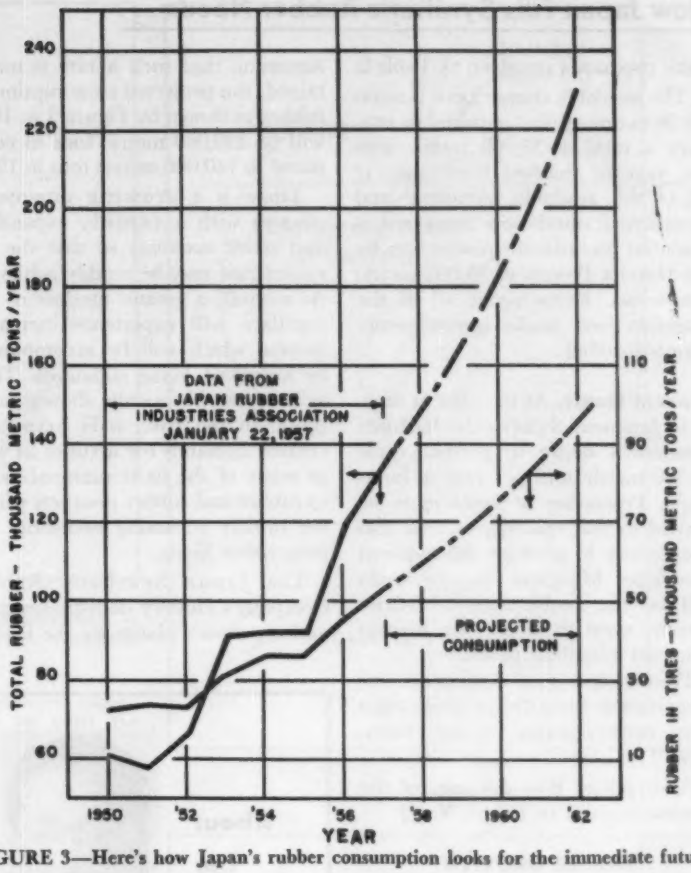

FIGURE 3—Here's how Japan's rubber consumption looks for the immediate future.

Additional fresh feed is obtained by simple deisobutanization of stocks containing isobutane and normal butane. Isobutane and small amounts of lighter material make up the overhead product and are available for use as LPG or fuel. The bottom of the tower is *n*-butane and constitutes the remainder of the required feed stock to the dehydrogenation plant.

The feed stocks most readily available to the Japanese Synthetic Rubber Co. plant at Yokkaichi are given by Table 1.

The butadiene plus potential buta-

TABLE 1—Available Feed Stock for Dehydrogenation

COMPONENT	METRIC TONS PER YEAR*			
	From Steam Cracking	From Catalytic Cracking	From Crude Topping Catalytic Reforming and Alkylation	Total
Propylene	520	427	.....	947
Propane	165	229	7,872	8,266
Isobutane	653	18,545	12,573	31,771
Isobutylene	7,110	4,958	.....	12,068
n-Butylene-1	3,420	2,616	.....	6,036
Butadiene	10,530	.....	.....	10,530
n-Butane	236	6,640	38,278	45,154
n-Butylenes-2	5,950	6,516	.....	12,466
Pentane & Heavier	2,828	.....	.....	2,828
Total	31,412	39,931	58,723	130,066

* Anticipated average compositions and quantities.

diene producers are given by Table 2.

The available charge stock is notably in excess of that required to produce a total of 33,500 metric tons per year of finished butadiene. If all of the available butadiene and butadiene formers were recovered, a potential butadiene production by the Houdry Process of 48,000 metric tons exists. Recovery of all of the available feed stocks is not immediately justified.

Present Goals. At the present time, it is Japanese Synthetic Rubber Company's desire to produce only 33,500 metric tons per year of butadiene. Processing is therefore to be limited to that quantity of feed that is necessary to produce the required butadiene. Marginal charge stocks will be the isobutane-*n*-butane streams since these are the lowest potential butadiene producers.

Process flow and description for specification butadiene production have been reported in the literature.[1,2]

A simplified flow diagram of the process is given in Figure No. 2.

RUBBER GROWTH

From 1950 to 1957 the growth of rubber market in Japan, although sporadic, increased at an average annual rate of 12.8 percent. As shown in Figure 3, annual rubber consumption rose from approximately 60,000 to 140,000 metric tons per year during this period. This was accomplished in spite of the fact that from 1954 to 1955 the growth was nil. Rubber Consumption gained impetus during the years 1955 and 1957, during which the growth averaged 22 percent per year.

Although it is not reasonable to expect a continued increase at this latter rate, it is not unreasonable to expect the Japanese rubber consumption to increase at a rate at least equal to the average prevailing during the seven-year period.

TABLE 2—Available Butadiene and Butadiene Producers

COMPONENT	Metric Tons/Year
n-Butylene-1	6,036
Butadiene	10,530
n-Butane	45,154
n-Butylene-2	12,466
Total	74,186

Assuming that such a rate is maintained, the projected consumption of rubber as shown by Figure 3 in 1962 will be 230,000 metric tons as compared to 140,000 metric tons in 1957.

Japan is a growing progressive country with a rapidly expanding and stable economy so that the assumed rate may be readily achieved. As a result, a greater number of the populace will experience increased income which will be accompanied by improved living standards. This, as has been historically shown many times, in the past, will bring increased demands for luxuries as well as many of the basic materials such as rubber and rubber products which are rapidly becoming necessities for progressive living.

The Japan Synthetic Rubber Company's Houdry dehydrogenation and copolymer plants are the first in Japan set up to meet the demand for rubber and to give Japan some independence from natural rubber. Independence from natural rubber is becoming increasingly important at this time due to the political and international situations within and around the natural rubber producing areas. Upsets in these areas could lead to curtailment of available natural rubber and although this is an unlikely and unpleasant consideration it does point out the importance of the synthetic rubber plant to Japan's economical future.

In view of these points it is very likely that the Japan Synthetic Rubber Company's plant which is now under construction is only the first plant and that other similar plants may be expected in the future.

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[1] Hornady, G. F., "Economics of Houdry Dehydrogenation," PETROLEUM REFINER, Vol. 33, No. 12, p. 173, Dec. (1954).
[2] PETROLEUM REFINER, Vol. 36, No. 11, p. 294, Nov. (1957).

About the Authors

Kawasaki

Noll

Logwinuk

Dr. K. Kawasaki is managing director and manager of the Technical Division, Japan Synthetic Rubber Co., Ltd., a position he has held since 1957. He received his degree in chemical engineering from Tokyo Institute of Technology in 1932, and obtained his Ph.D. degree in 1950. Dr. Kawasaki was manager of Japan Synthetic Rubber's Technical Division and manager of the Fuji plant from 1951-57, and was director of Kyowa Sangyo Co.'s Sakai plant from 1946-51. He was manager of the Sakai plant from 1945-46.

H. D. Noll is director of foreign operations for Houdry Process Corp., Philadelphia, where he deals with foreign contacts and engineering. He attended the University of Colorado from 1920-23, and holds a B.S. Degree in petroleum engineering from the University of Pittsburgh. He has been with Houdry since 1948, and was previously with several other firms, including Socony Vacuum Oil Co. and Magnolia Petroleum Co. His experience totals 33 years.

Dr. A. K. Logwinuk is a sales engineer with Houdry Process Corp., Philadelphia, where he specializes in foreign engineering and sales. Holder of a B.S. degree in chemical engineering from Drexel Institute of Technology, M.S. degree in mechanical engineering from the University of Pennsylvania and Ph.D. degree in chemical enginering from Case Institute of Technology, he is a registered professional engineer in Ohio. Dr. Logwinuk has been a research associate with National Research Committee, Office of Scientific Research and Development; chemistry instructor, Drexel Institute; process engineer, A. G. McKee & Co.; senior process engineer, Houdry Process Corp.; and engineer, Research and Development Department, Texaco, Inc.

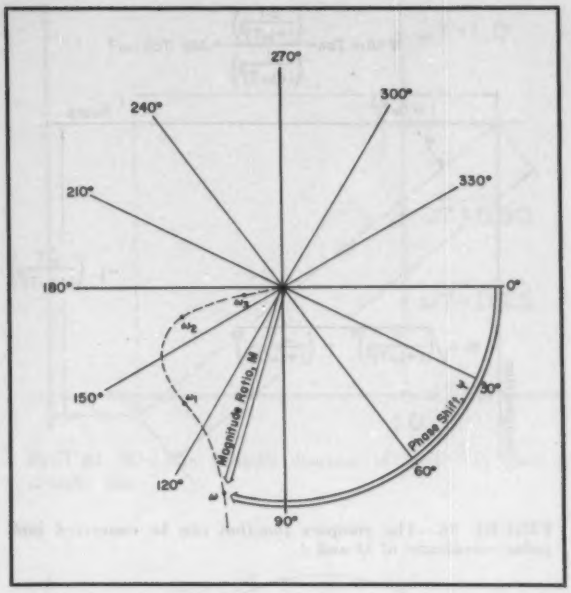

FIGURE 83—The frequency response for any frequency, ω, can be represented on a Nyquist diagram by a magnitude ratio, M, and a phase shift, ψ.

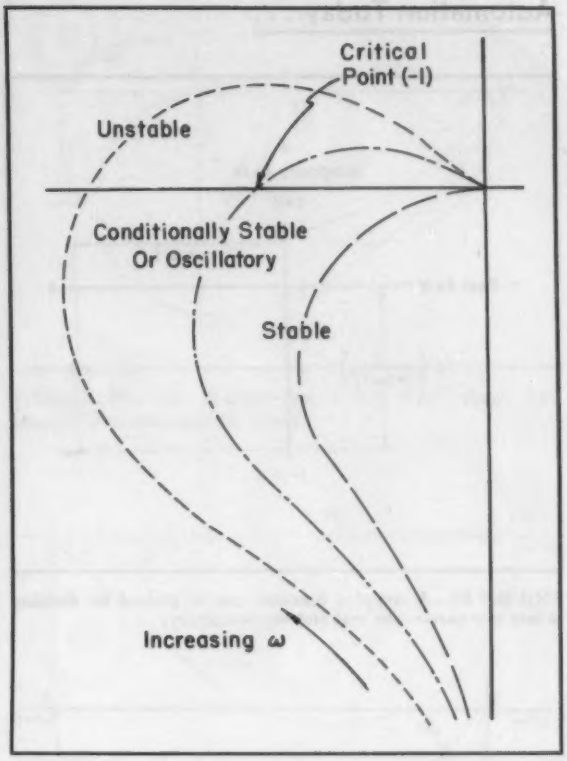

FIGURE 84—If the line of increasing frequencies (right) intercepts the axis to the right of the minus one point, the system is stable.

PART 15

Automation Today

Two methods are commonly used to determine controllers and check process stability. Here is a discussion of one of them —the Nyquist diagram

Theodore J. Williams and Verlin A. Lauher
Monsanto Chemical Co.
St. Louis

IN PREVIOUS ARTICLES we have listed two of the several methods which are available for using frequency response data to determine the proper controller to use on a process and to check the stability of the resulting process-controller complex. Those mentioned were the Bode and Nyquist methods.

The Bode diagram already has been discussed in detail (Part 5 and 6). Since the Nyquist diagram has many potential uses for which it is superior to the Bode diagram, we now wish to give an equally thorough development of the Nyquist diagram.

The Nyquist diagram was devised originally as an aid to electronic feedback amplifier design[1, 4] as was the Bode diagram.[2] One reason the automatic control field ad-

Part 16 Will Appear in An Early Issue of Refiner

THIS IS the beginning of another series of articles to acquaint you with some of the basic concepts of automatic control. The following parts will deal with several more advanced topics in the field. You may want to go back and review the earlier parts:

Parts	Automation Today	PETROLEUM REFINER
1- 4	Introduction to Process Control	April-July, 1956
5- 6	Using the Bode Diagram to Design	August-September, 1956
7-10	Application of Process Control	January-April, 1957
11-14	Using Computers and Test Methods	August-November, 1957

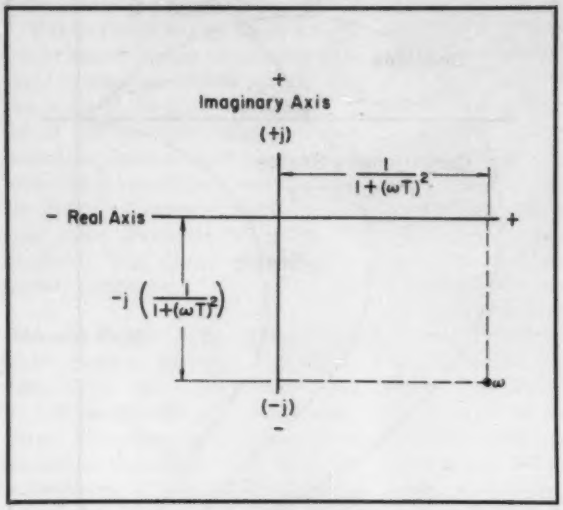

FIGURE 85—A complex function can be plotted by dividing it into two parts—one real and one imaginary.

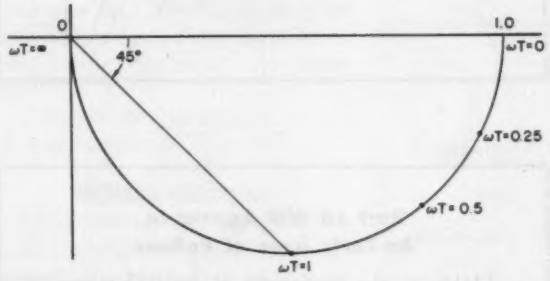

FIGURE 87—Every first order transfer function gives the same curve. Only the relation of position to time changes.

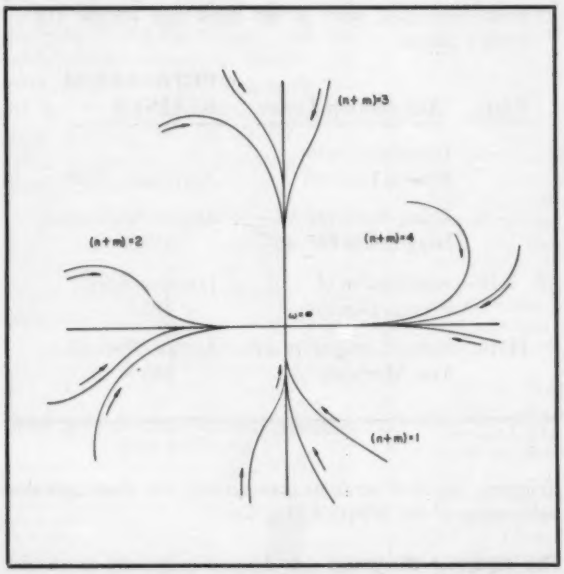

FIGURE 89—Here is how the exponent, n + m, influences the Nyquist plot of transfer functions.

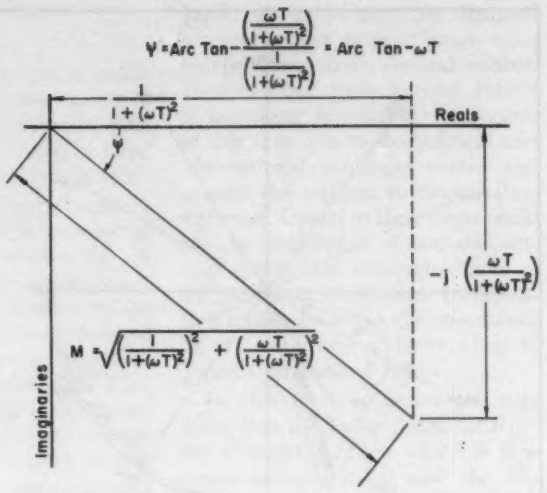
$\psi = \text{Arc Tan}\frac{\left(\frac{\omega T}{1+(\omega T)^2}\right)}{\left(\frac{1}{1+(\omega T)^2}\right)} = \text{Arc Tan} - \omega T$
$\frac{1}{1+(\omega T)^2}$
Reals
ψ
$-j\left(\frac{\omega T}{1+(\omega T)^2}\right)$
$M = \sqrt{\left(\frac{1}{1+(\omega T)^2}\right)^2 + \left(\frac{\omega T}{1+(\omega T)^2}\right)^2}$
Imaginaries

FIGURE 86—The complex function can be converted into polar coordinates of M and ψ.

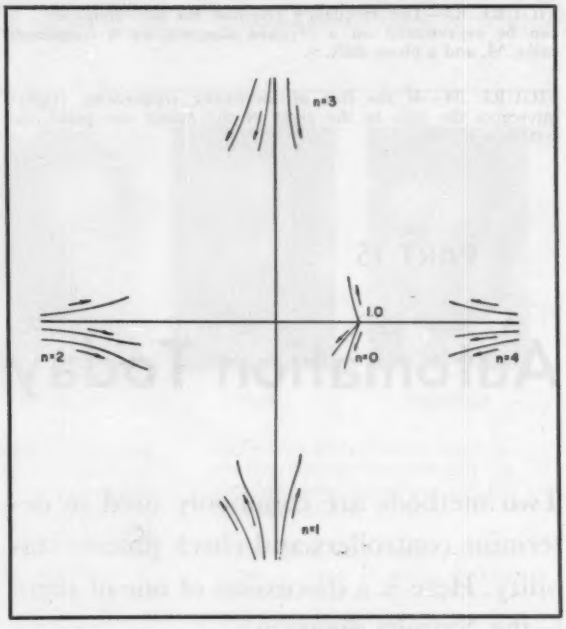

FIGURE 88—The exponent, n, determines the nature of the curve. The arrows show the direction of increasing frequency.

vanced as rapidly as it did during World War II, and since, has been due to the fact that investigators found the techniques so laboriously derived during the nineteen twenties and thirties for feedback amplifier design were almost immediately applicable to automatic control system theory. This plus the fortunate coincident development of electronic computers has resulted in the truly astonishing advancements which we see today.

The Nyquist diagram is a plot on polar graph paper of the transfer function of the system being studied. The magnitude ratio, M, of the system is plotted as the radius vector while phase shift, ψ, is plotted in degrees clock-

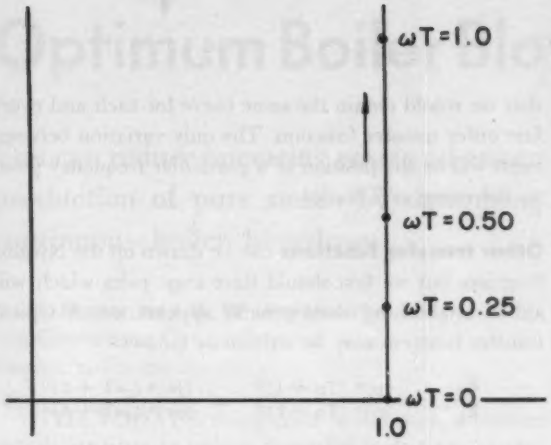

FIGURE 90—The Nyquist diagram of $(j\omega T+1)$ gives a straight line.

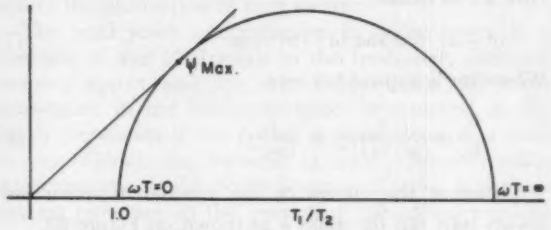

FIGURE 92—A typical derivative control network may have a transfer function of $\frac{j\omega T_1+1}{j\omega T_2+1}$ where T_1 is larger than T_2.

wise from the right hand abscissa as shown in Figure 83. Thus a point exists for each separate frequency and the frequency response of the system is one line on the graph rather than two as was required with the Bode diagram.

The Nyquist diagram also gives a ready indication of the stability of the system whose frequency response is being plotted. The "minus one point" (i.e. $M=1$ at $\psi=180°$) has been shown to be the critical point for stability of any controlled system. That is the magnitude ratio of the system must be less than 1 whenever the phase lag of the system is equal to or greater than 180°.

A ready rule for determining stability on the Nyquist diagram then follows: Proceed along the frequency response plot in the direction of increasing frequency, ω. If you pass the (—1) point with it on your left, the system is stable, if on your right, unstable, and if you pass through the (—1) point, the system is oscillatory or conditionally stable (Figure 84).

PLOTTING ON THE NYQUIST DIAGRAM

In plotting transfer functions on the Nyquist diagram, one uncovers the first difficulty involved in its use - - - there are no general direct asymptotic methods available for plotting as there were with the Bode diagram. Thus

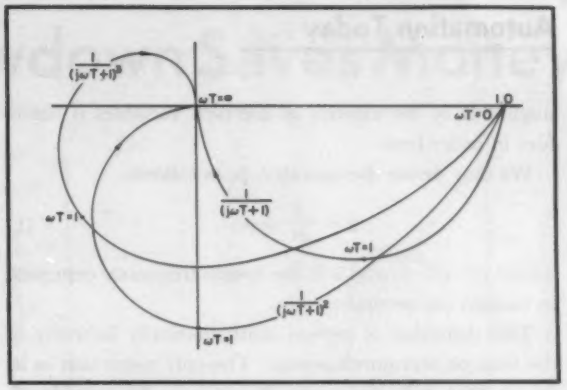

FIGURE 91—The diagram for $1/(j\omega T+1)^m$ shows how changes of m influence the curves.

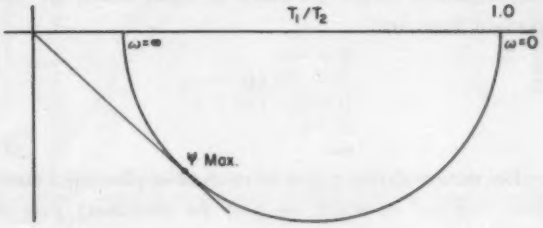

FIGURE 93—This is for the same transfer function as shown in Figure 92 with the exception that T_2 is larger than T_1.

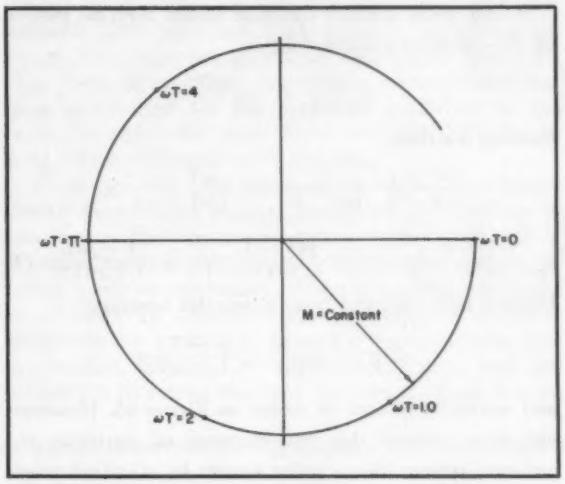

FIGURE 94—Dead time or true time delay of a control network may be represented by $e^{-j\omega T}$.

the respective magnitudes and phase shifts for each frequency must be worked out by the methods of the algebra of complex variables or a Bode diagram must be plotted first and the information derived from it for further plotting on the Nyquist diagram.

The asymptotic method of plotting to obtain the Bode diagram has already been described in Part 5. A short

discussion of the algebra of complex variables is therefore in order here.

We may define the operator, p, as follows:

$$p = \frac{d}{dt} = j\omega \qquad (1)$$

where $j = \sqrt{-1}$, and ω is the system frequency expressed in radians per second.

This definition is proven mathematically in many of the texts on servomechanisms.[3] The only restriction in its use is that only sinusoidal inputs may be considered. Since we are discussing only frequency responses at this point, this is not a difficult limitation.

Because of its definition, j assumes several interesting mathematical properties. Some of them which are important here are:

$$\begin{aligned} &j^2 = -1 \\ &j^3 = (j^2)\ (j) = -j \\ &j^4 = (j^2)\ (j^2) = 1 \\ &j^5 = j \\ &\text{etc.} \end{aligned} \qquad (2)$$

Let us now define a special method of plotting a complex function in which we plot the *imaginary part* of the function, that is, the part containing j, on the ordinate and the *real part* of the function, or that not containing j, on the abscissa of a two dimensional cartesian coordinate system as shown in Figure 85.

A first order transfer function would then be plotted on this complex plane as follows:

$$\frac{1}{Tp + 1} = \frac{1}{j\omega T + 1}$$

clearing fractions,

$$\frac{j\omega T - 1}{j\omega T - 1}\ \frac{1}{j\omega T + 1} = \frac{j\omega T - 1}{(j\omega T)^2 - 1} =$$

$$\frac{j\omega T - 1}{(j^2)\ (\omega T)^2 - 1} = \frac{j\omega T - 1}{(-1)\ (\omega T)^2 - 1} = \frac{1 - j\omega T}{1 + (\omega T)^2} \qquad (3)$$

Divided into *reals* and *imaginaries* this becomes:

$$= \frac{1}{1 + (\omega T)^2} - j\,\frac{\omega T}{1 + (\omega T)^2}$$

and would be plotted as shown on Figure 85. However, one may convert this two dimensional cartesian coordinate system into a polar system by standard trigonometric methods as shown in Figure 86.

Notice that we have now defined a magnitude ratio, M, and a phase shift, ψ, for the first order transfer function. Comparison with a Bode diagram for equivalent frequencies will show that these are indeed the correct M and ψ for the first order transfer function and we have by this method derived the true Nyquist diagram relationships. The complete first order curve is shown in Figure 87. Note that it becomes a perfect half circle and that the j component is largest at a phase lag of 45° or where $\omega T = 1$. The reader should note also that we would obtain the same curve for each and every first order transfer function. The only variation between them will be the position of a particular frequency point on the curve as T varies.

Other transfer functions can be drawn on the Nyquist diagram, but we first should state some rules which will aid in establishing their general appearance. A typical transfer function may be written as follows:

$$\frac{E_o}{E_i} = \frac{(p)^a\ (Tp + 1)^b}{(p)^c\ (Tp + 1)^d} = \frac{(j\omega)^a\ (j\omega T + 1)^b}{(j\omega)^c\ (j\omega T + 1)^d} \qquad (5)$$

We know from our previous considerations that stability requires that

$$(a + b) < (c + d). \qquad (6)$$

Now let us define

$$(c - a) = n, \text{ and } (d - b) = m \qquad (7)$$

Whenever ω approaches zero

$$\frac{E_o}{E_i} \cong \frac{1}{(j\omega)^n\ (1)^m} \cong \frac{1}{(j\omega)^n} \qquad (8)$$

Therefore the curves of the transfer function will always start out for small ω as shown on Figure 88.

On the other hand, whenever ω becomes large

$$\frac{E_o}{E_i} \cong \frac{1}{(j\omega)^n\ (j\omega T + 1)^m} \cong \frac{1}{(j\omega)^{n+m}} \qquad (9)$$

In that case the Nyquist plot curves will approach the center of the diagram (i.e. large ω) as shown on Figure 89.

Note that for the first order transfer function of Figure 87, $n = o$, and $(n + m) = 1$.

Figures 90 through 94 show typical Nyquist diagrams for several types of functions. Figure 91 compares the curves for successively higher order transfer functions and emphasizes the fact that magnitudes and phase shifts are no longer additive as they were on the Bode diagram. This as we mentioned before is the chief drawback of the Nyquist plotting system. It has several advantages, however, in its use when compared to the Bode diagram thus justifying its use. These will be enumerated in succeeding articles since our discussion here was for the purpose of acquainting the reader with the Nyquist diagram and the appearance of several functions when plotted on it.

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[3] Evans, W. R., *Control System Dynamics*, McGraw-Hill Book Company, New York, 1954, pages 39-43.

[4] Nyquist, H., "Regeneration Theory," *Bell System Technical Journal*, 11, 126-147 (January, 1932).

TO BE CONTINUED

Optimum Boiler Blowdown Saves Money

You can reduce operating costs and assure production of pure steam by optimizing continuous boiler blowdown

N. H. Prater and D. W. Antonacci
The Chemstrand Corporation
Pensacola, Florida

WITH TODAY'S rising costs in industry, a vigilant search for ways to reduce operating costs must be pursued. Optimizing boiler continuous blowdown is one factor which should be considered in any industrial plant utilizing steam generating facilities. This is necessary not only to reduce operating costs, but also to assure the production of pure steam.

The total solids concentration in boiler water is a function of the total solids in the feedwater, chemical treating agents, and the rate of blowdown. All solids introduced in the feedwater must be removed in the boiler blowdown if the system is maintained in a state of equilibrium. An increase in total allowable solids concentration in the boiler water will allow a proportionate reduction in the amount of blowdown required at a constant solids concentration in the feedwater. When a high percentage of boiler make-up water is required, it is desirable to carry boiler-water solids as high as possible in order to reduce the amount of blowdown. Conversely in systems where make-up is small, the quantity of blowdown is all so small, and the solids concentration is maintained at low values. This is shown by Equation (1):

$$B = \frac{S_F}{S_B - S_F} \times 100 \qquad (1)$$

Where: B = Percent blowdown based on steam generated
S_F = Total solids concentration in feedwater
S_B = Total solids concentration in boiler water

The calculation of percentage blowdown required to maintain a predetermined boiler water concentration is simplified by the use of the nomograph shown in Figure 1.

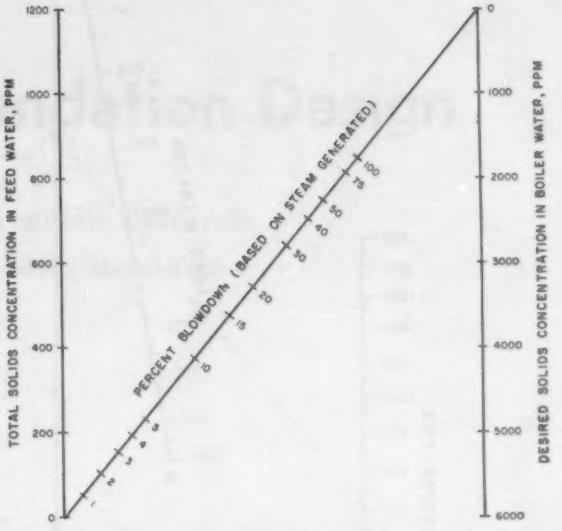

FIGURE 1—This nomograph simplifies calculating the percent blowdown required to maintain desired solids concentration in boiler water.

The limiting concentration of solids in boiler water varies with different types of boilers, rates of steaming, uniformity of steam load and character of concentrated solids. In practice, the limiting concentration varies between 1,000 ppm and 3,500 ppm, or approximately 60 to 200 grains per gallons of total solids (dissolved plus suspended). When the limiting concentration has been determined for the operating conditions of the boiler, enough water must be blown from the boiler to hold the concentration below this limit.

There are two principal types of boiler water blowdown—intermittent manual blowdown and continuous blowdown. The continuous system is the more widely accepted method since it gives dependable control of boiler water concentration within the acceptable limits at all times. In addition, it is important that excessive blowdown be avoided to minimize the heat units that are wasted, quantity of make-up feedwater and the additional chemicals required. Because of these factors,

Why Boiler Blowdown?

THE PRIMARY purpose for boiler blowdown is to lower the total solids contents of the boiler water so that the steam quality will not be impaired by carryover which is described as "foaming" or "priming" and to prevent the deleterious effects of the solids on boiler components. These solids enter the boiler in the feedwater stream and normally will not leave with the essentially pure steam. As a result, solids concentration in the boiler increases. The level of solids concentration in the feedwater depends on the type of water treatment employed. However, the trend in water treatment is to produce the purest water possible at a cost that can be justified for the particular conditions involved.

Total solids in the boiler water can be determined by evaporation and weighing. The evaporation of a sample as collected will give total solids and the evaporation of a filtered sample, the dissolved solids. For control purposes, dissolved solids can be estimated by comparison with any soluble constituent, such as chlorides or sulfates. The relation between such soluble constituents and the total solids should be established at frequent intervals by evaporation. Dissolved solids also be determined with an accuracy sufficient for routine control by electric conductivity.

Optimum Boiler Blowdown Saves Money . . .

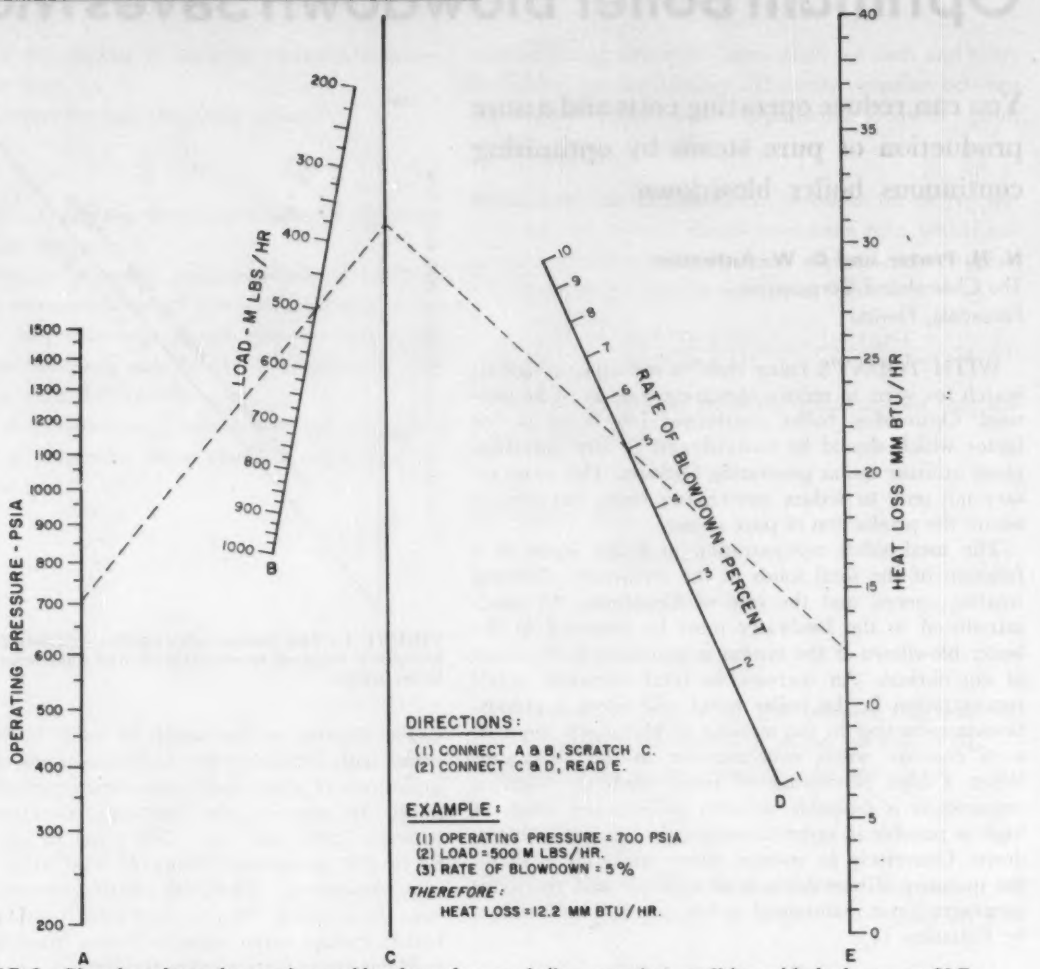

FIGURE 2—Gives heat losses for continuous blowdown for any boiler operating condition with feedwater at 60 F.

it is essential that the blowdown be controlled within very narrow limits to maintain boiler water concentration consistently at the optimum value.

It is beneficial in any plant to evaluate all pertinent factors in establishing optimum blowdown. Material savings in fuel and water consumption and chemical treatment can be realized by the application of proper control. An example calculation is included to illustrate the savings in heat units only through a reduction in blowdown. To obtain a complete economic study of the total savings by maintaining optimum boiler blowdown, the cost of water, and the initial and supplementary water treatment costs are to be added to the heat savings. Since these additional savings vary with the geographical plant locations, a study to include these savings is beyond the scope of this article.

Example Calculation

Boiler Load	500,000 lbs/hr
Boiler Pressure	700 psia @ 850° FTT
Feedwater Temperature	250 F.
Make-up Water Temperature	60 F.
Present Rate of Blowdown	5 percent
Optimum Rate of Blowdown	3 percent
Boiler Efficiency	78 percent
Fuel (coal) at 13,500 Btu/lb at $8.50/Ton (delivered and fired)	
Heat of Liquid at Boiler Pressure	491 Btu
Heat of Liquid at 60°F	28 Btu/lb
Heat Required per pound of Feedwater (491-28)	463 Btu
Feedwater Required at 5 percent Blowdown $\frac{500{,}000}{1.00 - .05}$	526,316 lb/hr
Feedwater Required at 3 percent Blowdown $\frac{500{,}000}{1.00 - .03}$	515,464 lb/hr
Heat Loss at 5 percent Blowdown (26,316 x 463)	12,184,300 Btu/hr
Heat Loss at 3 percent Blowdown (15,464 x 463)	7,159,830 Btu/hr
Heat Savings at 3 percent Blowdown (12,184,300 — 7,159,800)	5,024,470 Btu/hr
At a Boiler Efficiency of 78 percent the heat utilized is 13,500 Btu/hr of Coal x 0.78 = 10,530 Btu	

$$\text{Coal Savings per day} = \frac{5{,}024{,}470 \text{ Btu}}{10{,}530 \text{ Btu/lb Coal}} \times 24 \text{ hr/day} = 11{,}452 \text{ lbs.}$$

$$\text{Monetary Savings} = \frac{11{,}452 \text{ lbs.}}{2{,}000 \text{ lbs/ton}} \times \$8.50/\text{Ton} = \$48.67/\text{day}$$

Practical calculation of the savings to be realized through optimum blowdown rate is simplified by using the accompanying nomograph shown in Figure 2. ##

New approach to...

Pressure Vessel Foundation Design

For vertical pressure vessels, the old middle third rule requires a safety factor of 3. These data show that a factor of 1.5 is quite in order

J. A. A. Cummins
Hudson Engineering Corp.
Houston

IF THE FULLEST economy is to be realized in the design of a foundation, a complete understanding of its action under various loading is required. This is particularly true when the wind loading resultant falls outside the middle third of the foundation cross section and uplift occurs. In this case, the soil pressure, or pressure on the soil, varies in a different manner than when the resultant falls inside the middle third. It is emphasized that a factor of safety against overturning of 1.5 is quite in order, whereas the middle third rule gave a factor of safety of 3. The use of this data will result in a precise, and hence more economical design and will be consistent with the safety factors derived from the American Standard Building Code Requirements A58.1—1955, and the ACI Building Code.

Advantages of Square Base. For vertical pressure vessel foundations, a square base is preferable to an octagonal or round base mainly because of the complications involved in laying out the steel. An octagonal base requires at least three layers of steel, one on top of the other, and consequently a greater depth of concrete.

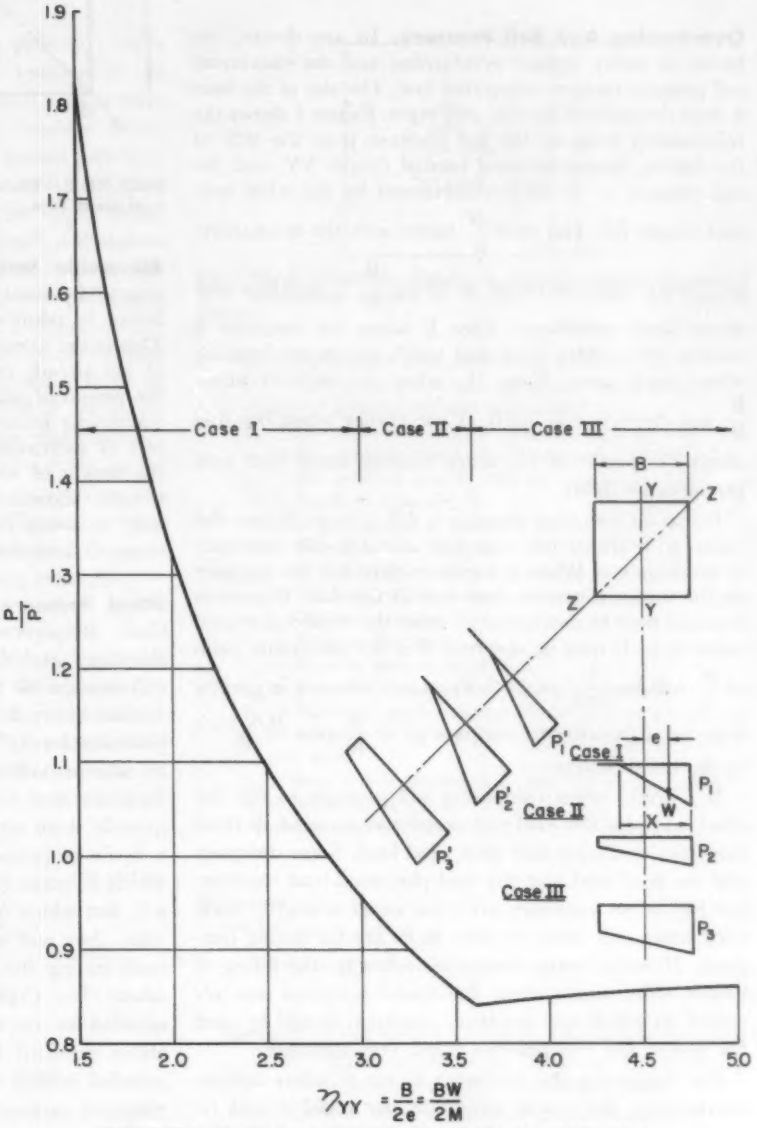

FIGURE 1—In Case 1 the resultant is outside the middle third.

The base area is practically the same in both cases, but the octagonal base uses considerably more steel. Furthermore, the form work for an octagonal base costs more than a square one of the same area. A square base also permits closer spacing of columns than the octagonal base.

The base must be set below ground, the bottom being below frost line and on undisturbed soil of known character. A pedestal is required to convey the load of the vessel to the footing. Ideally it should be circular, but an octagonal pedestal is cheaper to construct. The minimum depth below grade of the top of the footing is often governed by the depth required to accommodate the various pipes which are necessary wherever this type of vessel occurs.

Overturning And Soil Pressure. In any design, the factor of safety against overturning and the maximum soil pressure must be computed first. The size of the base is then determined by trial and error. Figure 1 shows the relationship between the soil pressure p at the side of the footing caused by wind normal to axis YY, and the soil pressure p′ at the corner caused by the wind normal to axis ZZ. The ratio $\frac{p}{p'}$ varies with the eccentricity and hence with the factor of safety $\frac{B}{2e} = \eta$. The curve shows three conditions: Case I, when the resultant is outside the middle third and uplift occurs for bending about both axes; Case II, when e_{yy} is less than $\frac{B}{6}$, but there is still uplift at the corner when bending about ZZ; and Case III, when bending about both axes produces no uplift.

It can be seen that about $\eta = 2.8$, $p = p'$. Below this value, p′ is always less than p so that it is only necessary to investigate p. When η is greater than 2.8, the pressure on the corner is greater than that at the side. The curve is useful here to determine p′ from the easily calculated value of p. It may be observed that the maximum ratio of $\frac{p'}{p}$ will be $\frac{1}{0.84} = 1.19$. For cases where η is greater than 3.6, it is easier to compute $p' = \frac{W}{B^2}$ plus $\frac{M \times 6\sqrt{2}}{B^3}$ in the usual manner.

It is usual when computing soil pressure to test for dead load plus test load with water and no wind, or dead load plus operating load plus wind load. Some designers still use dead load plus test load plus wind load together, but this is not necessary since the vessel is usually filled with water only once or twice in its life for testing purposes. However, some companies advocate the filling of vessels with water when hurricane warnings are received, in which case the latter condition should be used for design, but this practice is not very common.

For computing the minimum factor of safety against overturning, the empty weight of the vessel should be used together with the weight of the soil and footing.

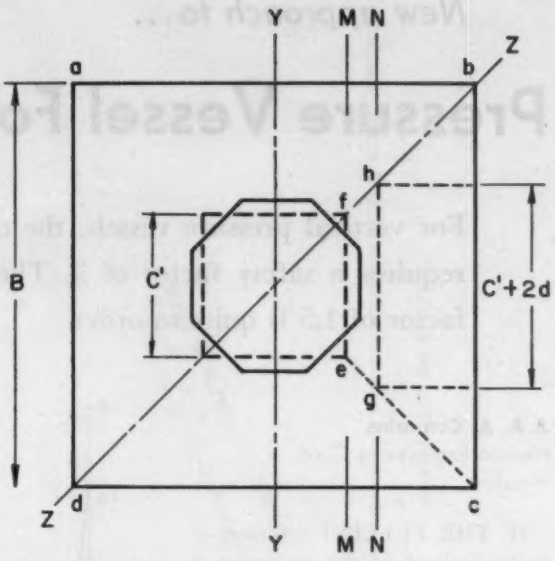

FIGURE 2—The octagonal pedestal is reduced to a square of equivalent area.

Allowable Soil Pressure. Allowable soil pressures quoted by most soil engineers are usually given as a figure in pounds per square foot at a certain depth. This is the allowable pressure in addition to the weight of soil already there. Thus, allowance can be made for the weight of original soil above foundation depth when computing maximum soil pressure. This has a net effect of increasing the given allowable soil pressure by the weight of soil above the given depth. If this figure is used, allowance must be made for all backfill which may lie above the foundation as well as the weight of concrete and maximum weight of the vessel.

Wind Pressure. The American Standard Building Code Requirements for Minimum Design Loads in Buildings and Other Structures, A58.1—1955, is the culmination of much study of wind pressures in the United States and contains recommendations for design pressures for different areas. It shows how wrong it is to take an arbitrary wind pressure and apply it to all localities and to any height above ground as it frequently done today. Specification writers often specify a figure of pounds per square foot on a projected area which in many cases is too high for the majority of vessels, but which for very tall vessels, is actually too low. Also, they will sometimes specify a wind velocity and omit stating the height at which the velocity is to be taken. The Code gives design wind pressures recommended for any location in the U.S. and for any height above ground level. In addition, minimum recommended seismic factors are given and a schedule for recorded earthquakes in the U.S. with a map showing the locations of their epicenters.

Concrete Design. The concrete base should be designed according to the latest ACI Building Code (ACI 318-56). In Figure 2, the bending moment on the footing is calculated on Section MM and the diagonal tension on NN with bending about YY axis. The octagonal pedestal is reduced to a square of equivalent area and the length of the side $C' = 0.91 \times$ dia. of an octagon. It can be shown that by turning the equivalent square through 45 degrees and investigating bending about the ZZ axis, the moment is never more than $\sqrt{2} \times M_{MM}$. Since the two-way footing will be designed for bending about YY, the components of the steel in the diagonal direction will be $2 \times \frac{1}{\sqrt{2}} = \sqrt{2} \times$ the area of the steel in the YY direction. Consequently, bending about ZZ does not enter into the concrete design.

The ACI Code at present makes no difference for a square and rectangular footing in the location of the critical section for bending. It is suggested that a more correct estimate of moment for square footings would be obtained by taking moments of the loaded area bcef about Section MM and distributing the steel computed over (ef plus 2d) where d is the effective depth of the base. This is particularly true with a small pedestal on a large base. The steel outside this critical section could then be placed at wider spacings. At present, the ACI Code specifies the moment to be taken and the steel to be distributed evenly over the full breadth of the base on Section MM. The diagonal tensile stress is to be computed from area bcgh on Section NN of width gh. The computation of bending moment and diagonal tension about these sections is best handled by use of formulae. These must vary according to whether the conditions are Case I or Case II (see Figure 1). Case III will be similar to Case II. The method of design is probably best illustrated by the following examples:

EXAMPLES

A typical absorber is taken, for example, with foundations to be located in (1) Nevada, (2) Oklahoma, (3) Central Texas (Figure 3). The vessel is 84 inches ID $\times$ 99 feet-6 inches S-S. The allowable soil pressure is 4000 PSI at 5 feet below grade. The shell thickness is 3.5 inches. Using 4 inch insulation gives 99 inches or 8.25 feet OD.

Erected weight empty	409,620 lbs.	$= W_e$	409,620 lbs.	W_e plus W_l = 438,420
Weight of water to fill	244,500 lbs.	$= W_w$		
Maximum vessel weight	654,120 lbs.	$= W_m$		
Operating liquid load		$= W_l$	28,800 lbs.	
Pedestal 9 feet-3 inches across flats; weight = 70.84 × 4.25 × 150		$= W_p$	45,100 lbs.	
Operating design load for mat		$= W_o''$	483,520 lbs.	

The following abbreviations have been used:

M_{wf} = Wind moment about bottom of footing at center, lb. ft.

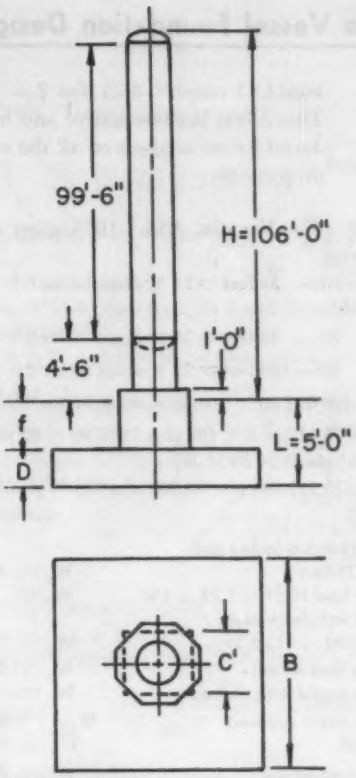

FIGURE 3—Example Figure. A typical absorber is studied with foundations located in Nevada, Oklahoma and Central Texas.

M_e = Earthquake moment bottom of footing, lb. ft.
C' = Side of square of equivalent area to octagon, ft.
S_g = Soil pressure for mat design, PSF
S_o = Soil pressure due to total operating load, PSF
S_t = Soil pressure due to total test load, PSF
S_w = Soil pressure due to wind or earthquake, PSF
D = Depth of concrete, ft.
d = Depth of steel in concrete, inches
B = Side of square base, ft.
η_{min} = Minimum FOS against overturning
η_o = Operating FOS against overturning
e_o = Operating eccentricity, ft.
V_n = Shear at Section N, lbs.
V_m = Shear at Section M, lb/ft
M_m = Moment in footing on Section M, lb ft/ft
S_a = Allowable stresses in accordance with ACI Code, psi
M_u = Moment in footing due to uplift at Section M, lb ft/ft
Σ_o = Sum of bar perimeters in one foot width, inches
S_s = Shear stress, psi
f = Depth of soil above base, ft.

Notes. (1) Unit weight of soil in calculations has been taken at 90 lb/cu ft, being the probable minimum weight if unconsolidated.
(2) For wind moment calculation allow 2 feet width for ladders, pipe, platform, etc., i.e.

total OD vessel = 8.25 plus 2 = 10.25 feet. This 2 feet is conservative and may be reduced by an analysis of all the extraneous projections.

Example (1)—Nevada. A58-1-1955 gives a 20 PSF pressure zone.

Wind pressure 0 — 30 feet = 15 × shape factor 0.6 = 9 PSF on vert. proj.

30 — 50 feet = 20 × shape factor 0.6 = 12 PSF

50 — 100 feet = 25 × shape factor 0.6 = 15 PSF

100 feet up = 30 × shape factor 0.6 = 18 PSF

M_{wf} = 10.25 (18 × 6 × 108 plus 15 × 50 × 80 plus 12 × 20 × 45 plus 9 × 30 × 20)

= 10.25 (11,664 plus 60,000 plus 10,800 plus 5,400) = 900,606 lb/ft

Let B = 19 feet-6 inches and D = 1.75 feet

Weight of base $19.5^2 \times 1.75 \times 150$	W_o = 483,520 lbs.
Weight of soil above base $90 \times (280 - 71)\ 3.25$	W_b = 99,820 lbs.
Operating load on soil	W_s = 90,380 lbs.
Operating liquid load —deduct	W_o = 673,720 lbs.
Minimum direct soil load	W_l = —28,800 lbs.
Water to fill	W_{min} = 644,920 lbs.
Max. test load on soil	W_w = 244,500 lbs.
Soil pressure under test load	W_t = 889,420 lbs.
	2,341 PSF

As Nevada is a region of recorded earthquakes, see A58.1—1955, a seismic factor of 0.1 is taken.

M_e = 0.1 (438,420 × 58.5 plus 144,920 × 2.5)

= 2,564,750 plus 362,300

= 2,927,050 lb. ft/ft.

This moment must be used since it is greater than M_{wf}.

$$\eta_{min} = \frac{W_{min} \times B}{2 M_e} = \frac{644{,}920 \times 19.5}{2 \times 2{,}927{,}050} = 2.15 > 1.5$$

$$\eta_o = \frac{W_o \times B}{2 M_e} = \frac{673{,}720 \times 19.5}{2 \times 2{,}927{,}050} = 2.24$$

$$e_o = \frac{M_e}{W_o} = \frac{2{,}927{,}050}{673{,}720} = 4.35 \text{ feet}$$

From curve, $\eta_o < 2.8$ and $\frac{p}{p'} > 1$ i.e. max soil pressure at side

$$\text{Soil pressure} = \frac{4 W_o}{3B\ (B\text{-}2e)} = \frac{4 \times 673{,}720}{58.5 \times 10.8} = 4{,}265 \text{ PSF}$$

Subtract wt. of original soil at given depth 90×5 = 450

Max. soil pressure 3,815 PSF < 4,000

Concrete design for 2,500 psi at 28 days

f_c = 1,125 f_s = 20,000

adding 33⅓ percent overstress for ACI 603(c)

f_c = 1,500 f_s = 26,667

For D = 1.75; let d = 17 inches; C′ = 0.91 × 9.25 = 8.42

For $\eta_o < 3$, proceed as follows:

X = 1.5 ($B\text{-}2_e$) = 1.5 × 10.8 = 16.2

Y = ½ (B — C′ — d/6) = ½ (19.5 — 8.42 — 2.83) = 4.13

$$V_n = \frac{2 W_o'' Y}{B \times^2}\left[\tfrac{1}{2}\ (C' \text{ plus } d/6)\ (2X - Y) \text{ plus } Y/3\ (3x - y)\right]$$

$$= \frac{2 \times 483{,}520 \times 4.13}{19.5 \times (16.2)^2}$$

$$\left[\tfrac{1}{2}\ (8.42 \text{ plus } 2.83)\ (32.40 - 4.13) \text{ plus } 1.28\ (48.60 - 4.13)\right]$$

= 780 (159.08 plus 56.92) = 168,480 lbs.

$$S_s = \text{Shear Stress} = \frac{V_n}{(12C' \text{ plus } 2\ d)\ jd}$$

$$= \frac{168{,}480}{(101 \text{ plus } 34)\ 0.867 \times 17} = 85 \text{ PSI} < 100$$

$$M_m = \frac{u^2 W_o''}{3BX^2}\ (2X \text{ plus } u) \text{ where } u = \frac{B - C'}{2}$$

u = ½ (19.5 — 8.42) = 5.54

$$M_m = \frac{(5.54)^2\ 483{,}520}{58.5 \times (16.2)^2}\ (32.40 \text{ plus } 5.54) = 36{,}700 \text{ lb. ft/ft}$$

W_p = 45,100 lbs.

99,820 lbs.

$W_b + W_p$ 144,920 lbs.

$$\text{Steel in bottom} = \frac{12 M_m}{S_s \times jd} = \frac{12 \times 36{,}700}{26{,}667 \times 0.867 \times 17}$$

= 1.12 in.²

Use No. 7 @ 6 inches on centers

$$KF = 260 \times 12 \times \frac{17^2}{12} = 75{,}300 > M \text{ — no compression steel}$$

$$\text{check bond: } V_m \cong \frac{4 M_m}{(B - C')} = \frac{4 \times 36{,}700}{11.08} = 13{,}250 \text{ lbs./ft}$$

$$\text{bond stress} = \frac{V_m}{jd\ \Sigma_o} = \frac{13{,}250}{0.867 \times 17 \times 5.5} = 163 \text{ PSI} < 267$$

The formula for uplift is approximate and applies only when

$$x > \frac{B \text{ plus } C'}{2}$$

$$M_u = \frac{B^2}{8}\ (90 \text{ f plus } 150 \text{ D}) \left(\frac{3}{\eta_{min}} - 1\right)^2$$

$$= \frac{380}{8}\ (90 \times 3.25 \text{ plus } 150 \times 1.75)\ (0.396)^2$$

= 4,135 lb. ft/ft

$$\text{Steel in top } \frac{4{,}135 \times 12}{26{,}667 \times 0.867 \times 17} = 0.13 \text{ in}^2$$

Use No. 4 @ 12 inches on centers

KF > M ie no compression steel

V_u = (90 f plus 150 D) (B — x) = 555 × 3.3 = 1,850 lbs./ft.

$$\text{bond stress} = \frac{1{,}850}{0.867 \times 17 \times 1.6} = 79 \text{ psi ok}$$

Example (2)—Oklahoma. A58-1-1955 gives a 40 PSF pressure zone.

Wind pressure 0 — 30 feet 30 × shape factor 0.6 = 18 PSF on vert. proj.

30 — 50 40 × shape factor 0.6 = 24 PSF

50 — 100 50 × shape factor 0.6 = 30 PSF

100 up 60 × shape factor 0.6 = 36 PSF

$M_{wf} = 10.25\ (36 \times 6 \times 108 \text{ plus } 30 \times 50 \times 80 \text{ plus } 24 \times 20 \times 45 \text{ plus } 18 \times 30 \times 20)$

$= 10.25\ (23{,}328 \text{ plus } 120{,}000 \text{ plus } 21{,}600 \text{ plus } 10{,}800)$
$= 1{,}801{,}200$ lb. ft.

For B = 18 feet; D = 1.5; f = 3.5 W_e plus W_l = 438,420 lbs.

$W_p = 70.84 \times 4.5 \times 150 = 47{,}820$ lbs.
$\div B^2 = S_g = 1{,}501$ PSF

	W_o'' =	486,240 lbs.
Weight of base $18^2 \times 1.5 \times 150$	W_b =	72,900 lbs.
Weight of soil above $90 \times 3.5\ (324 - 71)$	W_s =	79,700 lbs.
Operating load on soil	W_o =	638,840 lbs.
Operating liquid load deduct	W_l =	—28,800 lbs.
Minimum direct soil load	W_{min} =	610,040 lbs.
Water to fill	W_w =	244,500 lbs.
Max. test load on soil	W_t =	854,540 lbs.
Soil pressure under test load	W'/B^2 =	2,637 PSF
Seismic factor 0.025 gives M_e	$\cong$	652,000 lb/ft $< M_{wf}$

$$\eta_{min} = \frac{610{,}040 \times 18}{2 \times 1{,}801{,}200} = 3.05$$

$$\eta_o = \frac{638{,}840 \times 18}{2 \times 1{,}801{,}200} = 3.19 \text{ and } e_o = \frac{1{,}801{,}200}{638{,}840} = 2.82 \text{ feet}$$

Consult curve for $\frac{p}{p'}$ for $\eta_o = 3.19$ and obtain $\frac{p}{p'} = 0.914$

$$\text{Soil pressure} = \frac{4\,W_o}{3B\,(B - 2e_o)} \div \frac{p}{p'} = \frac{4 \times 638{,}840}{54\,(18 - 5.64)} \times \frac{1}{0.914} = 4{,}189 \text{ PSF}$$

Subtract weight of original soil at given depth $90 \times 5 = -450$
(at corner) Max. soil pressure $= 3{,}739$
$< 4{,}000$ PSF

Concrete design for 2,500 psi concrete @ 28 days

$f_c = 1{,}125$ $f_s = 20{,}000$
and adding 33⅓ percent overstress for ACI 603 (c)
$f_c = 1{,}500$ $f_s = 26{,}667$

$C' = 0.91 \times 9.25 = 8.42$ feet B = 18 D = 1.5 d = 14 inches

$K = 1/B\ (C' \text{ plus } d/6) = 1/18\ (8.42 \text{ plus } 2.33) = 0.6$

$$S_w = \frac{M_{wf} \times 6}{B^3} = \frac{1{,}801{,}200 \times 6}{(18)^3} = 1{,}853 \text{ PSF}$$

$$\text{Max. shear } V_n = \frac{B^2}{12}(1 - K)\ [3\,S_g\,(K \text{ plus } 1) \text{ plus } 2\,S_w\,(K^2 \text{ plus } K \text{ plus } 1)]$$

Note: if $S_w < \frac{1}{3}\,S_g$, then let $S_w = 0$ and allowable shear stress $S_s = 75$ PSI

if $S_w > \frac{1}{3}\,S_g$, compute V_n as above and $S_s = 100$ PSI

$$V_n = \frac{18^2}{12}(0.4)\ [3 \times 1{,}501\ (1.6) \text{ plus } 2 \times 1{,}853\ (0.36 \text{ plus } 0.6 \text{ plus } 1)]$$
$$= 10.8\ (7{,}205 \text{ plus } 7{,}264 = 156{,}265 \text{ lbs.}$$

$$\text{Shear stress } S_s = \frac{V_n}{(12\,C' \text{ plus } 2d) \times 0.867\,d} = \frac{156{,}265}{(101 \text{ plus } 28) \times 0.867 \times 14} = 99.9 \text{ PSI} < 100$$

$$\text{Design moment } M_m = \frac{S_g}{8}(B - C')^2 \text{ plus } \frac{S_w}{24\,B}(2\,B^3 - 3\,B^2\,C' \text{ plus } C'^3)$$

Note: if $S_w < \frac{1}{3}\,S_g$, then let $S_w = 0$ and allowable bending stress $S_b = 20{,}000$ PSI
if $S_w > \frac{1}{3}\,S_g$, compute M_m as above and $S_b = 26{,}667$ PSI

$$M_m = \frac{1{,}501}{8}(18 - 8.42)^2 \text{ plus } \frac{1{,}853}{24 \times 18}(11{,}664 - 8{,}175 \text{ plus } 595)$$
$$= 17{,}256 \text{ plus } 17{,}518 = 34{,}774 \text{ lb. ft/ft}$$

$$\text{Steel in bottom} = \frac{M_m \times 12}{S_b \times 0.867\,d} = \frac{34{,}774 \times 12}{26{,}667 \times 0.867 \times 14} = 1.29 \text{ in}^2\text{/ft.}$$

Use No. 8 @ 7 inches on centers

$$V_m \div \frac{4\,M_m}{B - C'} = \frac{4 \times 34{,}774}{18 - 8.41} \cong 14{,}490 \text{ lbs./ft } \Sigma_o = 5.4 \text{ inches}$$

$$KF = 260 \times 12 \times \frac{(14)^2}{12 \text{ steel}} = 50{,}960 > M, \text{ i.e. no compression}$$

$$\text{Bond stress} = \frac{V_m}{0.867\,d\Sigma_o} = \frac{14{,}490}{0.867 \times 14 \times 5.4} = 221 \text{ PSI} < 267$$

Note: if S_w had been $< \frac{1}{3}\,S_g$, allowable bond stress = 200 PSI

Uplift—Since $\eta_{min} > 3$, there can be no uplift. It is usual to provide nominal No. 4 @ 12 inch centers in such cases in the top of the mat, both ways.

Example (3)—Central Texas. A58-1-1955 gives a 25 PSF pressure zone.

Wind Pressure: 0 — 30	20 × shape factor 0.6 = 12 PSF
30 — 50	25 × shape factor 0.6 = 15 PSF
50 — 100	30 × shape factor 0.6 = 18 PSF
100 up	40 × shape factor 0.6 = 24 PSF

$M_{wf} = 10.25\ (24 \times 6 \times 108 + 18 \times 50 \times 80 + 15 \times 20 \times 45 + 12 \times 30 \times 20)$

$= 10.25\ (15{,}552 + 72{,}000 + 13{,}500 + 7{,}200)$
$= 1{,}109{,}580$ lb. ft.

For B = 16 feet-6 inch D = 1.5 f = 3.5

$W_o'' = 486{,}240 \div B^2 = S_s = 1{,}786$ PSF

Weight of base $16.5^2 \times 1.5 \times 150$	W_b = 61,260 lbs.
Weight of soil above $90 \times 3.5\ (272 - 71)$	W_s = 63,320 lbs.
Operating load on soil	W_o = 610,820 $\div B^2 = S_o$ = 2,244 PSF
Operating liquid load—deduct	—28,800 lbs.
Minimum direct soil load	W_{min} = 582,020 lbs.
Water to fill	W_w = 244,500 lbs.
Max. test load on soil	W_t = 826,520 $\div B^2 = S_t$ = 3,036 PSF

Seismic factor 0.025 gives $M_e = 651{,}960 < M_{wf}$

$$\eta_{min} = \frac{W_{min} \times B}{2\,M_{wf}} = \frac{582.020 \times 16.5}{2 \times 1{,}109{,}580} = 4.33 > 1.5$$

$$\eta_o = \frac{610{,}820 \times 16.5}{2 \times 1{,}109{,}50} = 4.54$$

As $\eta_o > 3.6$, proceed as follows:

$$S_w = \frac{M_{wf} \times 6}{B^3} = \frac{1{,}109{,}580 \times 6}{(16.5)^3} = 1{,}482 \text{ PSF}$$

Soil pressure (on corner) $= S_0 + 1.414\,S_w$
$= 2{,}244 + 2{,}096 = 4{,}340$ PSF

Subtract weight of original soil at given depth $90 \times 5 = -450$
$= 3{,}890$ PSF

Max. soil pressure $< 4{,}000$ PSF

Concrete design for 2,500 psi concrete at 28 Days.

$\eta_o > 3$, procedure similar to example (2).

Dowels. These must be provided to transfer any tensile force from the pedestal into the base. This force is transferred by bond from that part of the anchor bolts actually embedded in the pedestal. However it is usual to design dowels for the full tensile force whether the bolts go into the mat or not.

Let N = number of dowels in a circle Dd inches in diameter

Let M'' = the wind or earthquake moment at bottom of pedestal

Let A = area of each dowel; W_R = minimum resisting weight

$$\text{Then } A = \frac{(48/Dd)\,M'' - W_R}{S_A \times N}$$

For example (1),

$M'' = 0.1\,(438{,}420 \times 56.75 + 45{,}100 \times 2.25) = 2{,}600{,}470$ lb. ft.

$W_R = (W_e + W_P + W_L) = 483{,}520$

$$A = \frac{(48/104) \times 2{,}600{,}470 - 483{,}520}{26{,}667 \times 32} = \frac{716{,}700}{26{,}667 \times 32} = 0.84 \text{ in}^2$$

i.e., provide 2 at No. 9 and 2 at No. 8 at each of 8 pedestal faces.

For example (2), $M'' = \frac{(H/2) + L - D}{(H/2) + L} M_{wf} = \frac{56.5}{58} M_{wf}$

For cases where the depth of the base D is small compared to overall height of tower, M'' can be taken as Mwf

$W_R = (W_e + W_p) = 457{,}440$

$$A = \frac{(48/104)\ 1{,}801{,}200 - 457{,}440}{26{,}667 \times N} = \frac{373{,}890}{26{,}667 \times 32} = 0.44 \text{ in}^2$$

i.e., provide 4 at No. 6 at each pedestal face

For example (3),

$$A = \frac{(48/104 \times 1{,}109{,}580 - 457{,}440}{26{,}667 \times 16} = 0.13 \text{ in}^2$$

i.e., provide 2 at No. 4 at each pedestal face

Anchor Bolts. These may be computed as follows:

Let Db = diameter of bolt circle in inches.

N = number of bolts

M' = wind moment at base plate

W_R = minimum resisting weight

$$\text{Then Root Area } A = \frac{(48/Db)\,M' - W_R}{f_s \times N}$$

W_R is usually the empty weight W_e, but when the earthquake moment is used, W_R is the operating weight $W_e + W_L$

For example (1), Using SAE 4140 bolts with allowable stress 30,000 psi

$M' = 438{,}420 \times 52.5 = 2{,}301{,}700$ lb. ft.

$$A = \frac{(48/104)\ 2{,}301{,}700 - 438{,}420}{30{,}000 \times 20} = \frac{623{,}900}{600{,}000} = 1.04 \text{ in}^2$$

Use 20—1⅜-inch dia. bolts SAE 4140

For example (2),

$$M' \cong \frac{(H/2)}{(H/2) + L} M_{wf} = \frac{53}{58} \times 1{,}801{,}200 = 1{,}646{,}000 \text{ lb. ft.}$$

$$A = \frac{(48/104)\ 1{,}646{,}000 - 409{,}620}{30{,}000 \times 16} = \frac{350{,}070}{480{,}000} = 0.73 \text{ in}^2$$

Use 16 @ 1¼-inch dia SAE 4140

For example (3) $M' \cong \frac{53}{58} \times 1{,}109{,}580 = 1{,}013{,}930$

$$A = \frac{(48/104)\ 1{,}013{,}930 - 409{,}620}{12{,}000 \times 12} = \frac{58{,}350}{144{,}000} = 0.41 \text{ in}^2$$

Use 12 @ 1 inch dia. carbon steel.
(⅞" dia would do here, but normally less than 1 inch would not be used) ##

About the Author

J. A. A. Cummins is a civil engineer working in design and construction for Hudson Engineering Corp., Houston. He attended Nautical College, Pangbourne, England, for four years—then went to Royal College of Science and Technology, Glasgow, Scotland, for four years to study civil engineering. He started his career with a consulting engineering firm in Scotland in 1947. From 1951-54 he was a concrete structural engineer in England, and from 1954-56 was an engineer and superintendent on a project to construct a dam in Scotland. He joined Hudson 2½ years ago in Ontario, and has been with the Houston office for a year. A registered professional engineer, Cummins is a member of several technical societies.

Use These Charts for Fast Pipe Sizing

These charts, developed from standard pipe flow equations, take much of the tedium out of sizing process pipe lines

G. C. Lammers, Stearns-Roger Mfg. Co., Denver
W. G. Otis, The Martin Co., Denver

PIPE SIZING is an onerous chore when a large number of lines must be designed. The following charts have been developed from standard, acceptable pipe flow equations to take some of the tedium out of such calculations, and to save time.

For gases, a factor F is first computed, which contains the design variables:

$$F = \frac{1000}{Z} \frac{(P_1 - P_2)}{L} \frac{520}{T} \frac{(P_1 + P_2)}{2\,(Sp\,G)}$$

With F and the flow in SCFM known, the required pipe size is directly obtainable from Figure 1 or 2.

The equations for liquids involve fractional powers of the liquid density and viscosity, which are conveniently handled by one of Figures 3, 4, 5, and 6, depending upon the pipe size range. The result is a factor C, which is then applied to Figure 7 along with the liquid flow in gpm to fix the required pipe diameter. The value of the factor C so obtained is for the special case of a pressure drop of one psi per 1,000 feet; for other hydraulic gradients, the C obtained must be multiplied by the desired pressure drop in psi 1,000 feet of pipe.

The charts for gases were derived from Weymouth's formula:

$$Q_o = 0.6917 \frac{T_o}{P_o} \left[\frac{(P_1^2 - P_2^2)\, D^{5.33}\, 1000}{TL\,(S_p\,G)\qquad Z} \right]^{1/2}$$

When T_o is 520 R and P_o is 14.7 psia, Weymouth's formula may be rearranged to give

$$Q_o^2 = 2.303\, FD^{5.33}$$

The inside diameters associated with the nominal pipe diameters plotted in Figures 1, 2, and 7 are given in the following table.

Nom. D Inches	Inside D Inches	Nom. D Inches	Inside D Inches	Nom. D Inches	Inside D Inches
1½	1.500	12	12.090	30	29.250
2	1.939	14	13.375	34	33.250
3	3.068	16	15.375	36	35.250
4	4.026	18	17.375	42	41.250
5	5.047	20	19.250	48	47.000
6	6.065	24	23.250	54	53.000
8	7.981	26	25.250	60	57.750
10	10.136				

For liquids, the familiar Darcy formula was used and converted to engineering units:

$$P_1 - P_2 = \frac{0.000215\quad f \rho\, LQ^2}{D^5}$$

Formulas used for f varied with the pipe diameter, as follows:

$f = 0.321/Re^{0.23}$, 1½-inch and 2 inch pipe[1]
$f = 0.295/Re^{0.23}$, 2½-inch through 4-inch pipe[1]
$f = 0.259/Re^{0.23}$, 6-inch through 12-inch pipe[1]
$0.3305/Re^{0.252}$, 14-inch through 60-inch pipe[2]

These formulas can be combined and rearranged to produce:

$$\frac{Q^{1.77}}{D^{4.77}} = \frac{35.746}{L} \frac{(P_1 - P_2)}{\mu^{0.23}\,\rho^{0.77}} = \text{C for } 1\tfrac{1}{2}\text{" and 2" pipe}$$

$$\frac{Q^{1.77}}{D^{4.77}} = \frac{38.896}{L} \frac{(P_1 - P_2)}{\mu^{0.23}\,\rho^{0.77}} = \text{C for } 2\tfrac{1}{2}\text{" through 4" pipe}$$

$$\frac{Q^{1.77}}{D^{4.77}} = \frac{44.303}{L} \frac{(P_1 - P_2)}{\mu^{0.23}\,\rho^{0.77}} = \text{C for 6" through 12" pipe}$$

$$\frac{Q^{1.748}}{D^{4.748}} = \frac{37.843}{L} \frac{(P_1 - P_2)}{\mu^{0.252}\,\rho^{0.748}} = \text{C for 12" through 60" pipe}$$

Caution: The graphs presented are valid for turbulant flow range only. If in doubt, check the Reynolds number; it must exceed 2,100.

Continued on next page

About the Authors

Lammers

G. C. Lammers is a process engineer in the Special Products division, Stearns-Roger Manufacturing Co., Denver. He works in the process design of chemical cryogenic and nuclear plants. Holder of B.S. and M.S. degrees in chemical engineering from South Dakota School of Mines and Technology and M.I.T. respectively, he has 14 years' experience in development, process design and economic evaluation. Lammers has been with Eastman Kodak Co., Bureau of Mines, Consolidation Coal Co., Texas Power and Light Co. and Stearns-Roger.

Otis

W. G. Otis is a system test engineer for The Martin Co., Denver, where he is in charge of mechanical facilities on a Titan missile test stand. Holder of a B.S. degree in mechanical engineering from Marquette University, he has worked for Stearne-Roger Manufacturing Co., as a piping designer, Platte Pipe Line Co. as Western district engineer, Great Lakes Pipe Line Co. as Southern district inventory engineer and as a structural designer, and with War Emergency Pipe Lines as a junior engineer. He has 11 years pipe line experience.

Use These Charts for Fast Pipe Sizing . . .

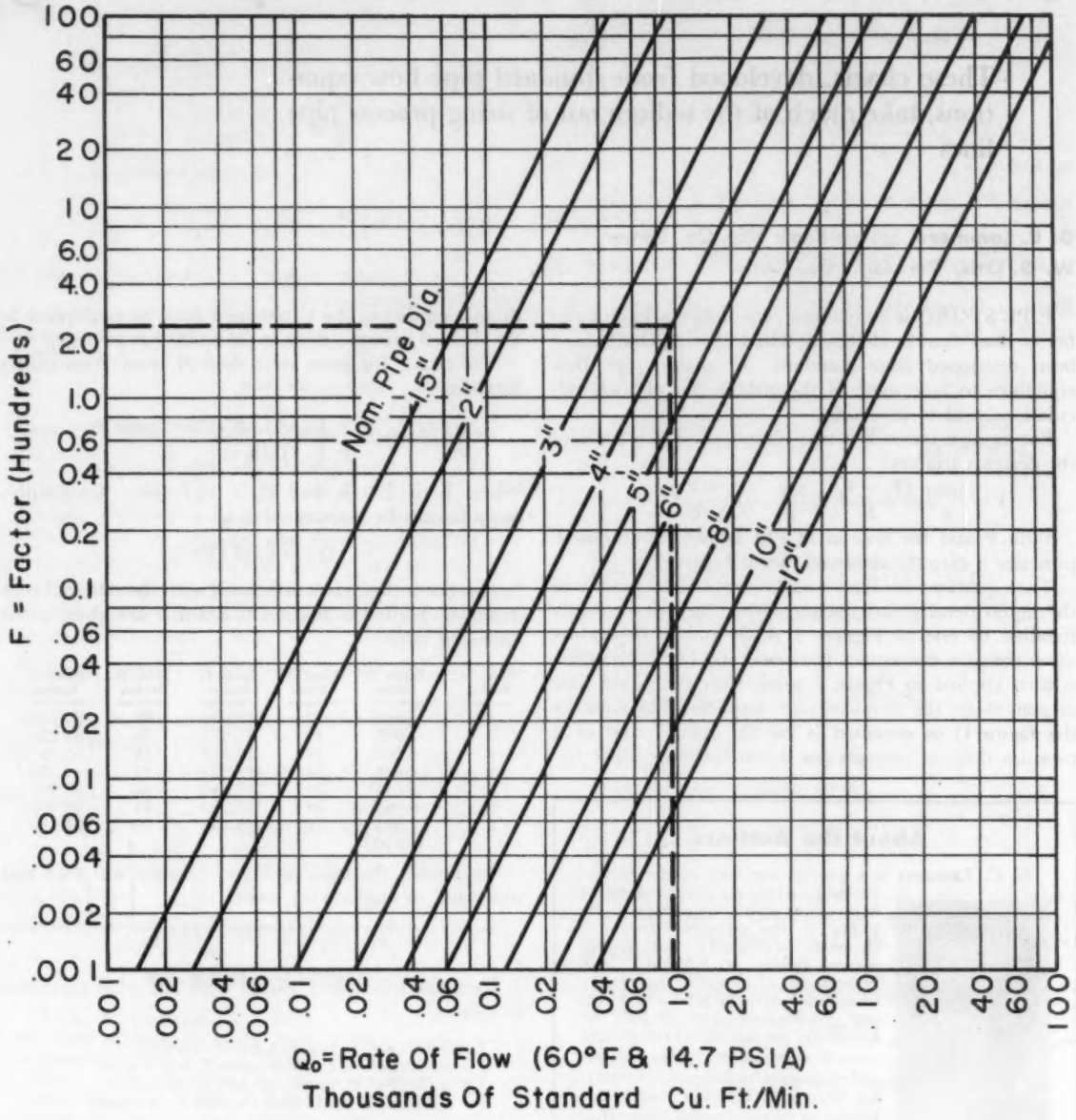

FIGURE 1—Use this chart for gases when sizing 1½-12-inch pipe lines.

Example 1

Nitrogen at 50 psig, 250 F., 950 scfm, and 5 psi/1,000 foot drop

P average $= 50 + 14.7 = 64.7$ psia

T $= 250 + 460 = 710$ R

Tr $= \frac{710}{227} = 3.73$

Pr $= \frac{64.7}{492.5} = .131$

Z $= 1.00$

Sp. G. $= \frac{28.016}{29} = .966$

F $= \frac{1000}{1.00} \times \frac{5}{1000} \times \frac{520}{710} \times \frac{64.7}{.966} = \frac{168,200}{686} = 245$

From Figure 1, 4-inch Sch. 40 pipe is called for.

Example 2

MEA at 120 F., 450 gpm, and 10 psi/1,000 foot drop

Sp. G. $= .999$

$\rho = .999 \times 62.4 = 62.3$ lb/cu. ft

$\mu = 7.49$ centipoise

From Figure 5 for 6 — 12-inch pipe

C = 1.15 for 1 psi/1,000 feet

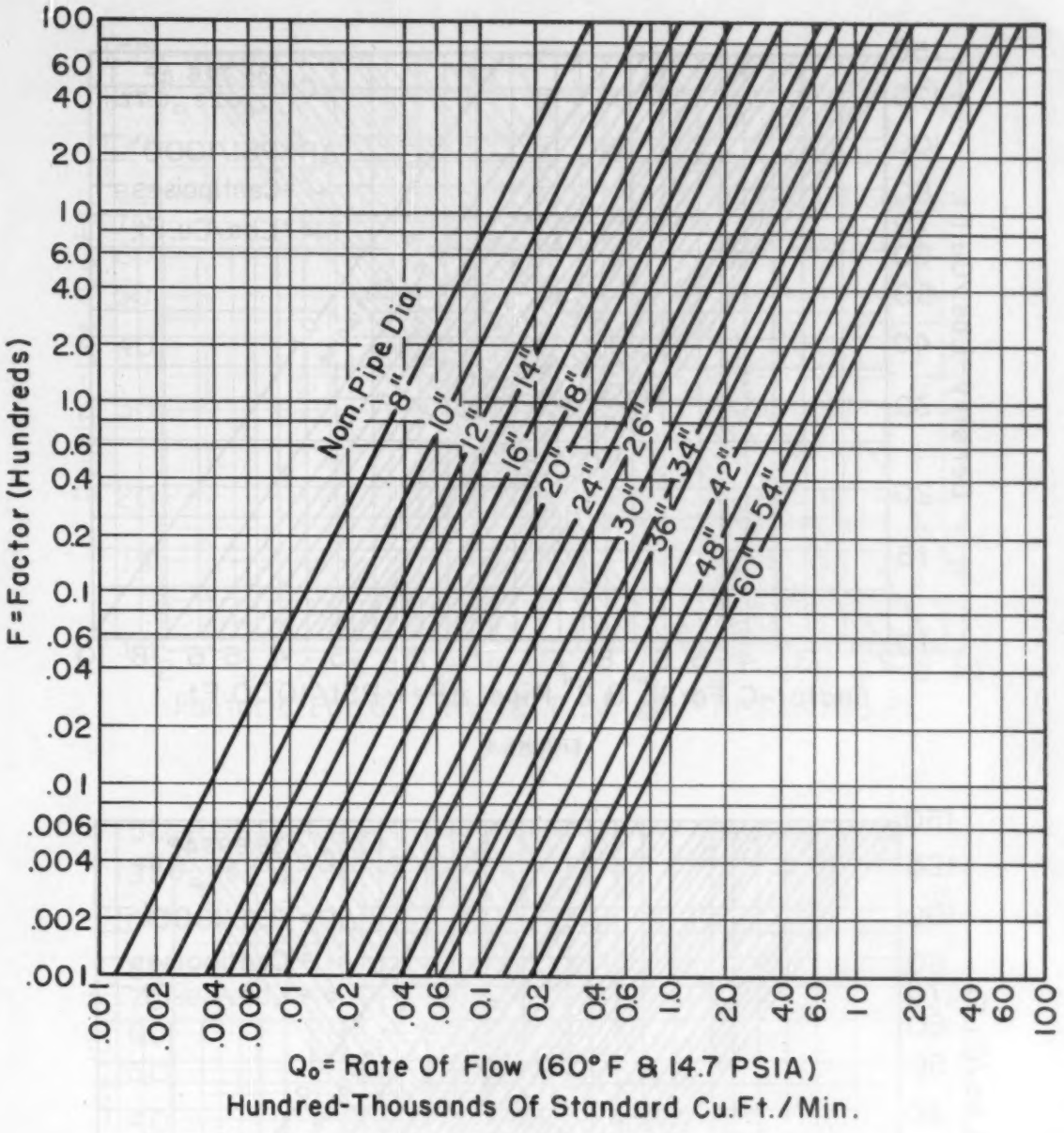

FIGURE 2—Use this chart for gases when sizing 8-60-inch pipe lines.

C = 11.5 for 10 psi/1,000 feet

From Figure 7 for liquids, a 6-inch Sch. 40 pipe is called for.

NOMENCLATURE

Q_o = Flow in cubic feet per minute measured at the base temperature and pressure.
T_o = Base temperature, °R. (Usually 520°R)
P_o = Base pressure, psia. (Usually 14.7 psia)
P_1 = Upstream pressure, psia.
P_2 = Downstream pressure, psia.
D = Inside pipe diameter, inches.
Sp. G. = Specific gravity of the gas flowing relative to air = 1.00 = molecular weight of gas/28.97.
T = Temperature of gas flowing, °R.
L = Length of pipe, equivalent feet.
Z = Compressibility factor in equation PV = ZNRT.
f = Friction factor.
ρ = Density of liquid flowing, lb./ft.[3]
L = Length of pipe, ft.
Q = Flow rate of liquid flowing, gpm.
μ = Fluid viscosity in centipoise.

$$Re = \text{Reynolds number} = \frac{50.7\,Q\,\rho}{D\,\mu}$$

LITERATURE CITED

[1] O'Brien, H. L., "Petroleum Tankage & Transmission" p 107, (1951) Graver Tank and Manufacturing Company.
[2] Anderson, L. E., *Oil and Gas Journal*, Page 63, Dec. 8, 1949.

Figures 3 through 7 on following pages

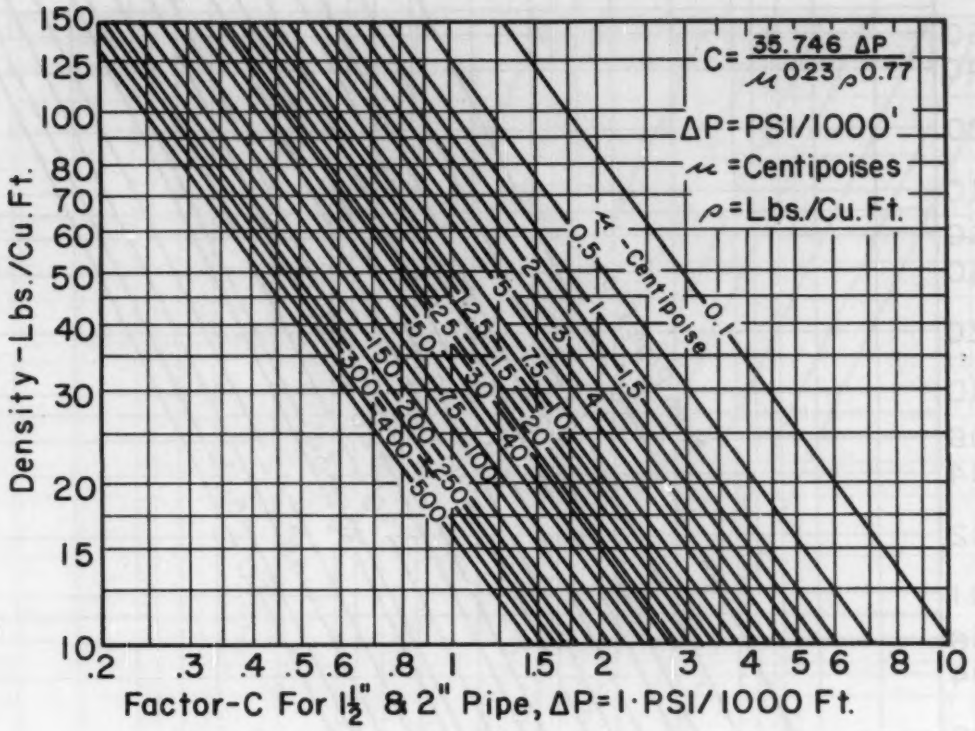

FIGURE 3

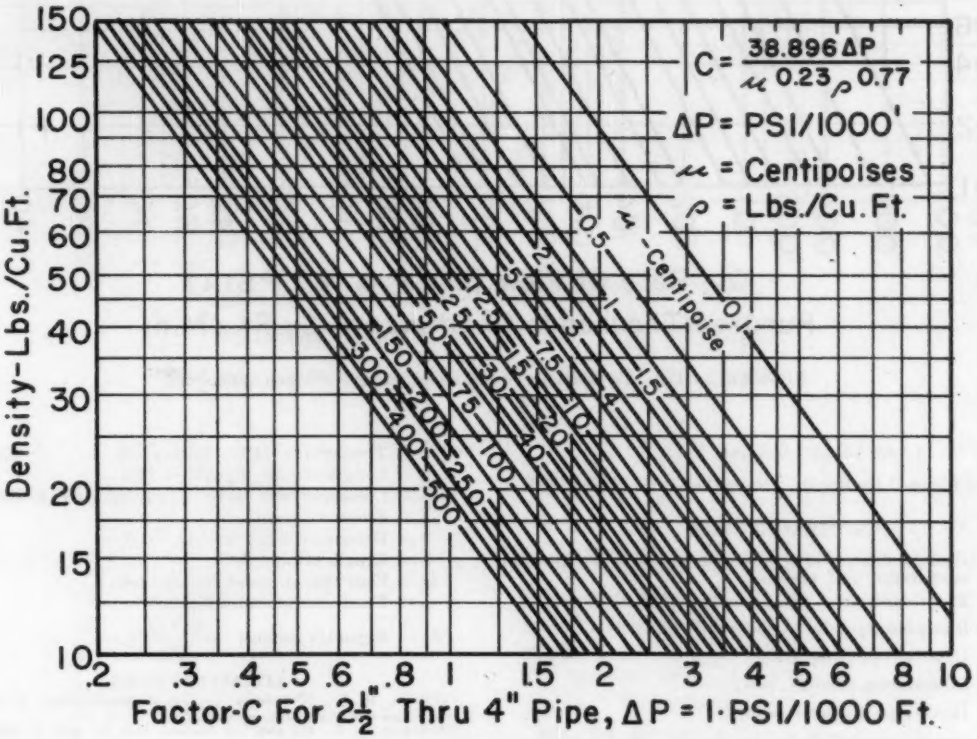

FIGURE 4

the C factor for using Figure 7 (next page) when sizing liquid lines

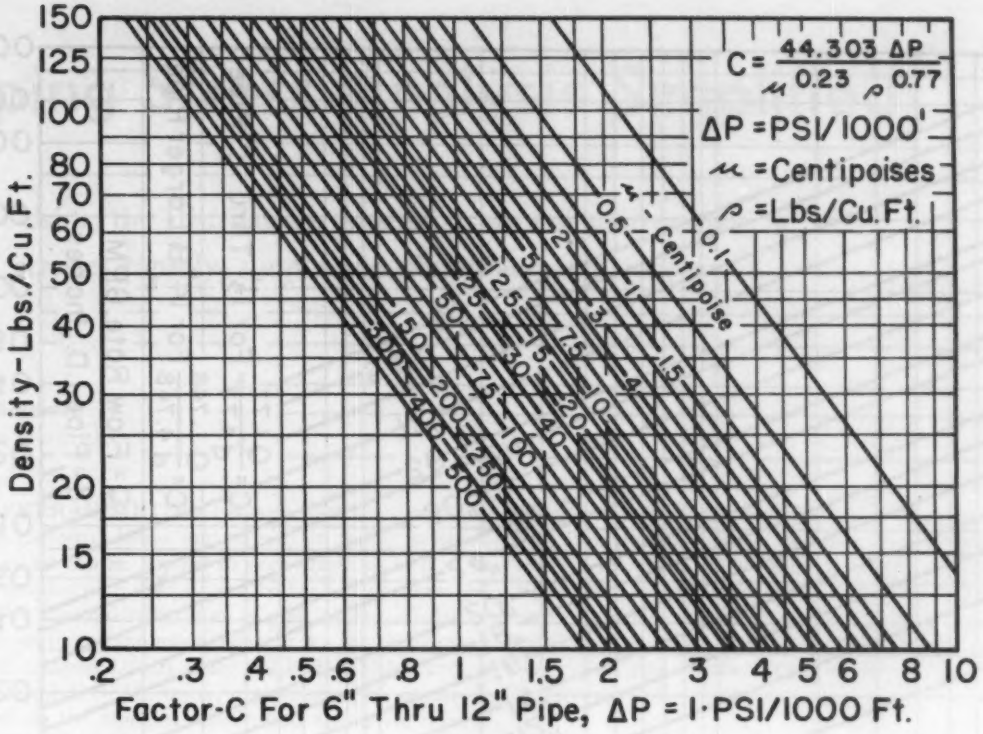

FIGURE 5

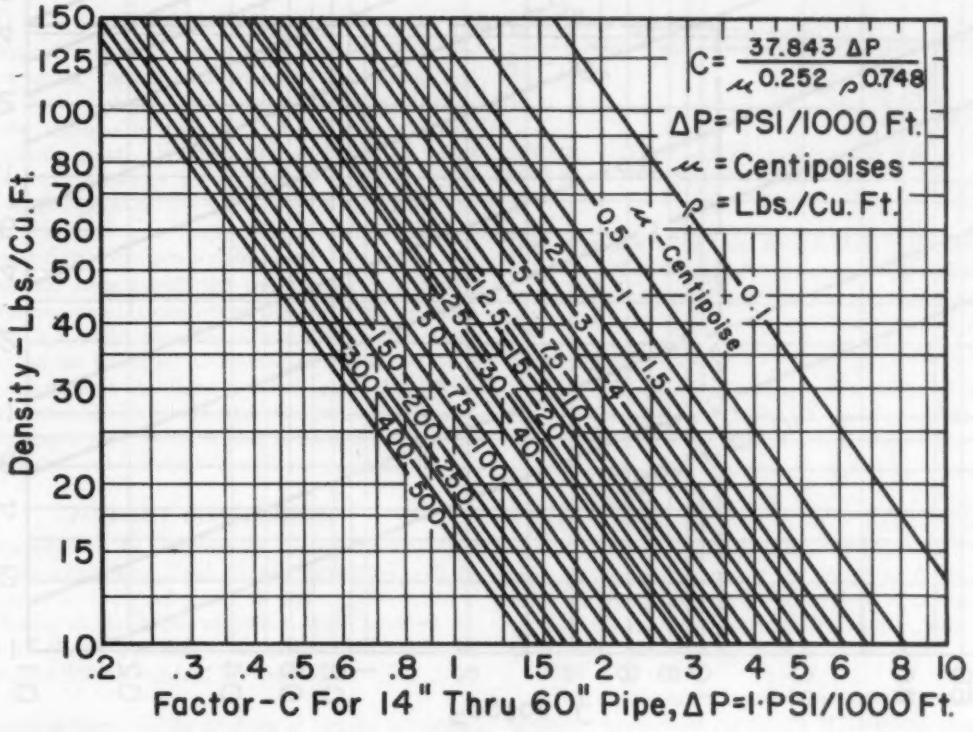

FIGURE 6

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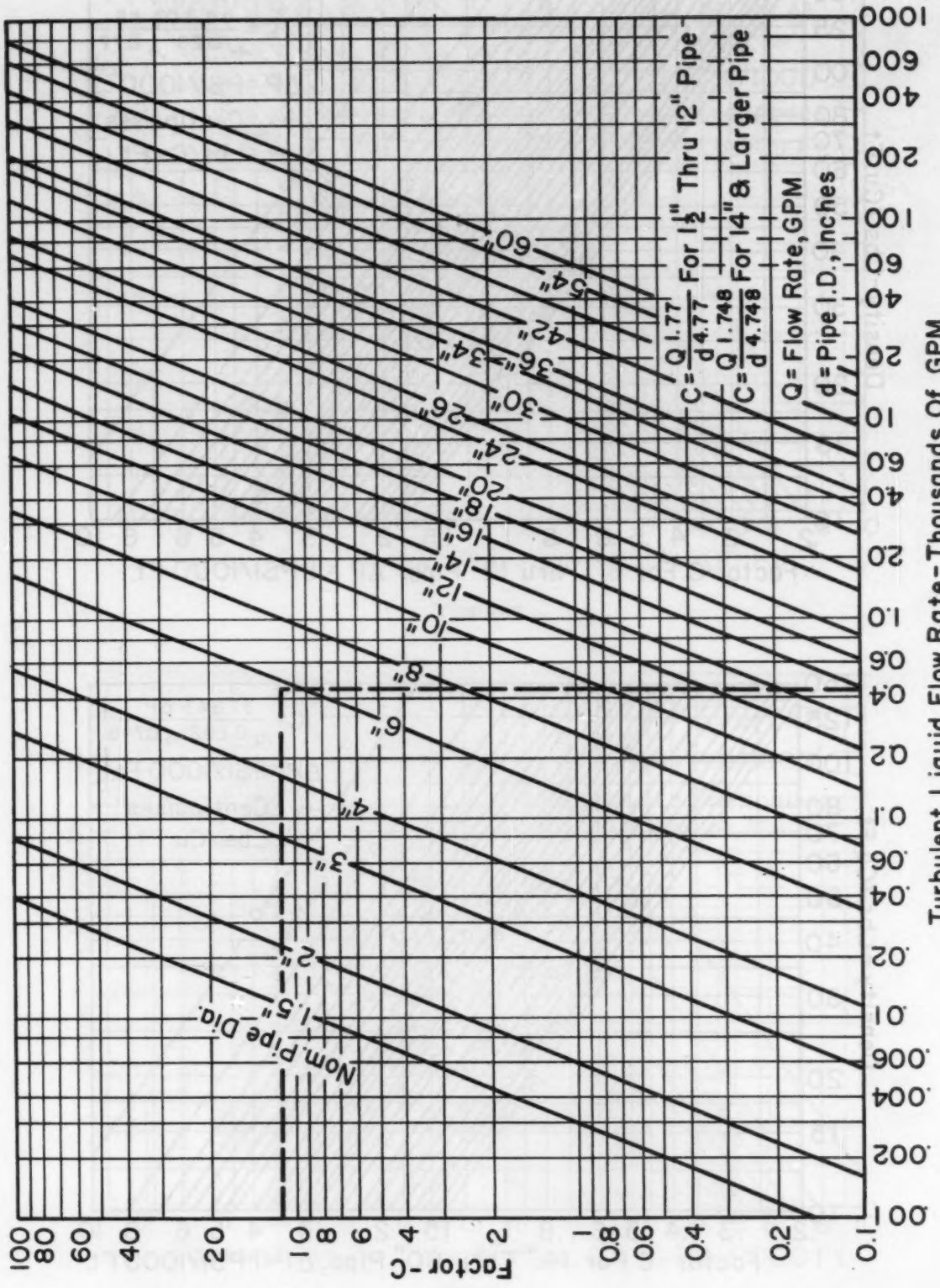

FIGURE 7—With the C Factor from Figures 3-6, use this chart for sizing liquid process lines.

Turbulent Liquid Flow Rate–Thousands of GPM

FIGURE 7—With the C Factor from Figures 3-6, use this chart for sizing liquid process lines.

Piping Stress Analysis Simplified

Using the distribution method, you can analyze piping stresses rapidly, simply and obtain accurate results

J. S. Moloney
Polymer Corp. Ltd.
Sarnia, Ont.

A GENERAL METHOD is presented for determining the moments forces and stresses in piping systems. The method can be applied to very simple as well as to more complex pipe lines. It can be used to evaluate the effects of thermal expansion as well as the effects of extraneous forces and movements. It is a relatively rapid method compared with other methods which claim a complete solution. Moreover, it gives accurate results. It is based on the moment distribution and stress relaxation methods of Hardy Cross[1] and of Southwell,[2] but contains certain features which make it a special adaptation of these.

INTRODUCTION

Of particular note are two items derived from the principles of the conventional moment distribution system. The first of these is the use of a simple ratio to denote the stiffness of two straight members acting simultaneously, relative to the stiffness of a single small elastic member to which they are both attached. Such a ratio makes possible the balancing of moments for the three members in a single step, after one conventional balancing operation for the joint.

The second item avoids the usual repetitious rebalancing of moments. It consists of the use of an *effective* length for a straight member, whose end remote from the joint to be balanced is connected indirectly to a fixed point, through an elastic member or members. This point of connection between the straight member and the other elastic member is treated as being fixed against translation, but only partially restrained against rotation.

MOMENT DISTRIBUTION

A knowledge of the conventional moment distribution method for analysis of rigid framed structures will be of assistance to the reader of this paper. This method can be found in text books on structures.[3] However, for the sake of clarity, certain of the basic principles of the moment distribution method are included.

First Assumptions. In the analysis of framed structures by moment distribution, straight members are taken to be prismatic bars, and Hooke's law is assumed to apply. The direction of rotation in which the moments at the ends of members act is shown by a sign convention. In this paper, an end moment is positive when the member tends to rotate the joint, or part to which the end in question is attached, in a clockwise direction. It is negative when the member tends to rotate the part in a counterclockwise direction.

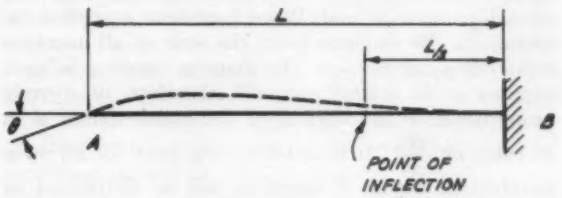

FIGURE 1—For a straight member with one end fixed, the point of zero moment is located at L/3.

The Member with One End Fixed. Referring to Figure 1, end B of the straight member is fixed against rotation and translation. If end A is fixed against translation only, and if an externally applied moment M acts at A, end A rotates an amount $\Theta = \frac{ML}{4EI}$, (where L, E and I are length, elastic modulus and moment of inertia of cross section respectively for the member). The member then takes up a new position (shown dotted).

The point of inflection, or point of zero moment for the member in Figure 1 is located ⅓ L from end B. Therefore, when the moment of + M occurs at end A, a moment of + ½ M results at end B. There is said to be a carry-over factor of + ½ from A to B. Shear force in the member of Figure 1 is equal to the sum of the end moments divided by length (which equals $\frac{M + \frac{1}{2}M}{L}$, or $\frac{M}{\frac{2}{3}L}$, or $\frac{\frac{1}{2}M}{\frac{1}{3}L}$).

When an externally applied moment causes a constant moment throughout the length of an elastic member, the total rotation (rotation of one end with respect to the

other end), is equal to $\frac{ML}{EI}$. Such a condition can be considered true in cases where the length of a member is negligibly small, or when a member is subjected to torsion. In determining stiffness in torsion for a member of circular cross section, the elastic modulus in shear, and the polar moment of inertia must be used.

Stiffness Ratios for Members at a Common Joint. For a given value of end rotation Θ (Figure 1), stiffness of the member is directly proportional to the resulting moment M, that is to $\frac{4EI}{L}$.

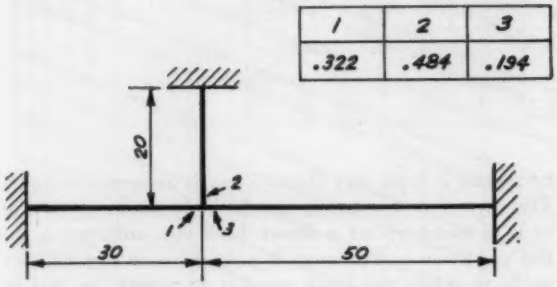

FIGURE 2—Three straight members rigidly attached together at a common joint with the other ends fixed.

In Figure 2, three straight members are rigidly attached together at a common joint while the other end of each member is fixed. When a moment is applied externally to the common joint, the ends of all members rotate an equal amount. The moment resulting in each member at its rotated end will, therefore, be directly proportional to the stiffness of the member, that is to its value of $\frac{4EI}{L}$. If E and I are the same for all three members of Figure 2, moments will be distributed as noted in the similarly numbered boxes. The sum of the moments resulting in the members at the joint will be equal in magnitude and opposite in sense to the externally applied moment.

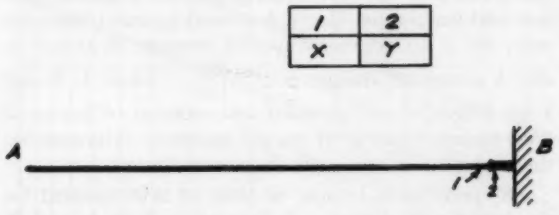

FIGURE 3—End B is fixed against translation and partially restrained against rotation.

The Member with One End Partially Fixed. End A of the straight member in Figure 3 is fixed against translation only. End B is fixed against translation and is partially restrained against rotation. This means that a second elastic member, shown as a very small member in Figure 3, is connected between end B and a fixed point. The relative stiffness or stiffness ratio for the two members joined together at B is X : Y as noted in the similarly numbered boxes.

Now supposing end A of the straight member in Figure 3 to be rotated slightly while end B remains fixed. Moment + M, say, results at A, moment $+\frac{M}{2}$ at B. Next, assume that the joint at B is made to rotate just enough so that the algebraic sum of all the moments in the members at the joint becomes zero. The moments at joint B are then said to be balanced. Final moments in the straight member will therefore be $\frac{M}{2} - \frac{XM}{2}$ at end B, and $M - \frac{XM}{4}$ at end A.

It can be seen that the straight member with the elastic member attached at end B is more flexible with respect to end A than the simple straight member rigidly fixed at end B, by the ratio $M : \left(M - \frac{XM}{4}\right)$. Or, considered with respect to end A, a straight member with a fixed remote end, $\frac{1}{1 - \frac{X}{4}}$ times the length of the straight member in Figure 2, would be equivalent in stiffness to the actual members shown in Figure 2. The bending moment resulting at remote end B in Figure 2, is $\frac{YM}{2}$, which is $\frac{Y}{2}\left(\frac{1}{1 - \frac{X}{4}}\right)$ times the final bending moment at A. Therefore, the carry-over factor is $\frac{Y}{2}\left(\frac{1}{1 - \frac{X}{4}}\right)$.

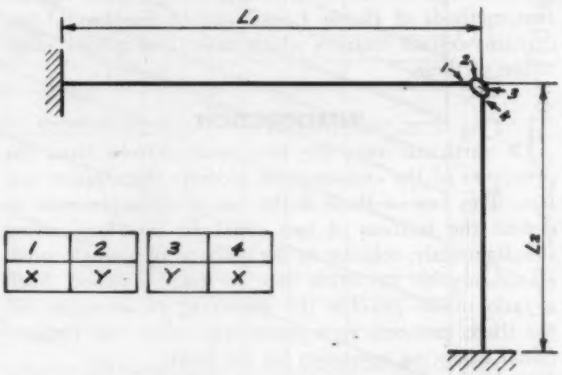

FIGURE 4—Two straight members are fixed at one end and joined together with a small, elastic member.

Small Member at a Corner Joint. Consider two simple straight members having the same moment of inertia, each rigidly fixed at one end, and joined rigidly together at the other end (Figure 4). Assume that moments at the joint are balanced; that is that moments of equal magnitude and opposite sense exist in the joint ends 1 and 4 of the straight members.

Assume then that the rigid joint itself (shown as a small dark area in Figure 4) is replaced by a small elastic member of the same size, while ends 1 and 4 of the straight members are prevented from rotating by some external device. There is then a joint between each straight member and the small elastic member at the corner—making two joints, 1 - 2 and 3 - 4. Moments at these joints are not balanced, but may be balanced by

a single operation. Such an operation means in effect that joint 1 - 2 must rotate in one direction, joint 3 - 4 must rotate simultaneously in the other direction. Such rotation must be just sufficient so that the sum of moments at each joint becomes zero. Also final moments at 1, 2, 3, and 4 must all be of equal magnitude.

It is apparent that some point within the corner member does not rotate during the balancing operation. Assuming this point to be fixed, the straight members may be considered to have partially fixed ends (as in Figure 3).

Note that the stiffness ratio X : Y (ratio of straight member stiffness to stiffness of a portion of the corner member), shown in the similarly numbered boxes in Figure 4, is the same for both joints. Now stiffness is a linear function of length for an elastic member. Therefore, the ratio of stiffness of a straight member (of the same section) of length $L_1 + L_2$, relative to the stiffness of the complete corner member is also X : Y. The ratio X : Y is, therefore, $\frac{1}{L_1 + L_2} : \frac{1}{4L_c}$ where L_c is the effective or virtual length of the corner member.

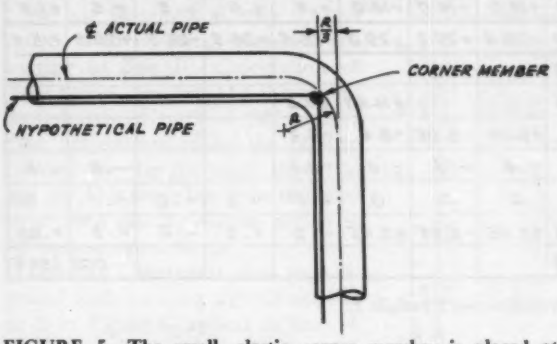

FIGURE 5—The small, elastic corner member is placed at R/3 from the actual pipe center lines.

Elbows. The flexibility of elbows is provided for in this method by small elastic corner members. Thus, a hypothetical pipe line, the working equivalent of the actual line, is used for flexibility calculations. The corner member is positioned at $\frac{R}{3}$ from the point of intersection of the actual straight run center lines (Figure 5).

When an actual elbow and its connected straight runs are subjected to pure bending (in plane bending), the value of effective corner member length to be used in the hypothetical line is $\frac{k\pi R}{2} - \frac{4R}{3}$ in which R is the radius of curvature for the elbow center line, and k is the flexibility factor.[4] On the other hand, when one of the straight runs only is in bending and the other straight run is in torsion (out-of-plane bending), the value of effective corner member length to be used is

$$\frac{\pi R}{4}\left(k + 1{\cdot}3\right) - \frac{4R}{3}.$$

Each of these values provides a total length of hypothetical line (straight runs plus effective corner member lengths), elastically equivalent to the total length of the actual line (straight runs plus effective elbow lengths).

DESCRIPTION OF METHOD

For a given pipe stress analysis problem, the appropriate hypothetical pipe line must first be determined.

The "fixed-end" moments then have to be calculated for the ends of certain members. To do this, the movement Δ (use the movement which occurs in the real line) due to total expansion (or other cause), parallel to the X-axis say, is assumed to cause deformation in bending in a single straight member (or in the smallest possible number of straight members), which is parallel to the Y or Z axis. The ends of the straight member subjected to bending are assumed not to rotate. Fixed-end moments M are therefore equal to $\frac{6EI\Delta}{L^2}$, where L, E, and I are for the member deformed. Similarly movements parallel to the Y and Z axes are each assumed to cause bending in a single member. The fixed-end moments are then calculated for the deformed members.

In the moment balancing procedure, plan and elevation views of the hypothetical line are treated independently. For a given view, moment balancing starts at a joint adjacent to one end of the line. At such a joint, moments are balanced first as though the corner member was rigid. This is done by distributing moments in proportion to the stiffness of the hypothetical straight runs connected at the joint. Next, moments are balanced simultaneously for the two straight members and the small corner member. This is done by distributing moments in proportion to the combined stiffness of the two straight runs, relative to the stiffness of the corner member. Ends of the straight runs remote from the joint are assumed to be rigidly fixed in these two steps.

The second and succeeding joints along the pipe line, for the view considered, are then treated in the same way, excepting for the remote ends of straight members extending back towards preceding joints. These remote ends must be treated as being partially restrained against rotation because of the elastic members to which they are attached (see above, "The Member with One End Partially Fixed"). After such balancing, the moments resulting at the ends of each member (algebraic sum of individual moments) must be found.

For each view, the shear force existing in each member (equal to sum of end moments divided by length of member) has to be calculated. The algebraic sum of the shear forces acting at each joint in each direction of its freedom, called an unbalanced shear force, must be found. Unbalanced shear forces, which are in effect equivalent to external forces acting at certain corners in the pipe line to hold it in position, must be eliminated. This is done by first finding the moments which result throughout the line due to a unit force acting in turn at each point where an unbalanced shear force was found. Then moments throughout the line resulting from forces equal to each unbalanced force in magnitude and direction, but opposite in sense, are determined and added to give final moments.

The procedure for finding moments which result from unit forces acting at significant points (corners in the hypothetical line) is as follows:

1. Apply a unit force to the line at a corner where an unbalanced shear force was found, and calculate the resulting fixed-end moments. (Fixed-end moments occur in at least two straight runs in this case.)

2. Balance moments throughout the line for the views where fixed-end moments exist.

			1	2	3	4	5	6	7	8	9	10
1	STIFFNESS RATIOS	STEP 1	+.500	.491			.509	+.500				
2		" 2	+.500	.587	.413	.413	.587	+.500				
3	DISTRIBUTION FACTOR / CARRY OVER FACTOR	" 3	-.064	-.127	+.127	-.127	+.127	.810			.190	+.500
4		" 4	-.064	-.127	+.127	-.127	+.127	.306	.694	.694	.306	+.500
5	FIXED END MOMENTS x 1/1000						-312.5	-312.5			+2.0	+2.0
6	DISTRIBUTION OF MOMENTS (FOR MOMENT BALANCING)	STEP 1	+77.0	+153.5			+159.0	+79.5				
7		" 2	-45.0	-90.0	-63.5	+63.5	+90.0	+45.0				
8		" 3	-9.5	-19.0	+19.0	-19.0	+19.0	+150.5			+35.5	+18.0
9		" 4	-.5	-1.5	+1.5	-1.5	+1.5	+11.5	+26.0	-26.0	-11.5	-6.0
10	TOTALLED MOMENTS (SHEAR FORCES UNBALANCED)		+22.0	+43.0	-43.0	+43.0	-43.0	-26.0	+26.0	-26.0	+26.0	+14.0
11	SHEAR FORCES (LBS.) (Σ S.F. = 987 LBS.↓)		1121 LBS.↑								134 LBS.↓	
12	CORRECTING MOMENTS ADDED		-43.0	-14.0	+14.0	-14.0	+14.0	-.5	+.5	-.5	+.5	+1.5
13	FINAL MOMENTS (SHEAR FORCES BALANCED)		+21.0	+29.0	-29.0	+29.0	-29.0	-26.5	+26.5	-26.5	+26.5	+15.5
14	FIXED END MOMENTS (DUE TO 1 LB.↓)		-28.8	-28.8							+1.1	+1.1
15	DISTRIBUTION OF MOMENTS (FOR MOMENT BALANCING)	STEP 1	+7.1	+14.15			+14.65	+7.3				
16		" 2	+4.3	+8.6	+6.05	-6.05	-8.6	-4.3				
17		" 3	+.2	+.4	-.4	+.4	-.4	-3.3			-.8	-.4
18		" 4	0	0	0	0	0	+.1	+.2	-.2	-.1	-.05
19	TOTALLED MOMENTS		-17.20	-5.65	+5.65	-5.65	+5.65	-.2	+.2	-.2	+.2	+.65
20	SHEAR FORCES (LBS.) (Σ S.F. = .397 LBS.↓)		.394 LBS.↑								.003 LBS.↑	

TABLE 1—Steps in the Procedure for Example 1.

3. Calculate shear forces for each member in each view, and determine unbalanced shear forces.

4. Repeat steps 1, 2, and 3 for each of the other points where an unbalanced shear force was found. (Note that a force applied to the pipe according to the above steps causes motion at the point where it was applied, but during the subsequent moment balancing all the joints remain in fixed position. Hence, there results a *force causing motion* at the point where the unit force was applied, and an *induced force* at each other corner in a direction of its freedom.)

5. Remove induced forces by the method of successive elimination of variables. Thus, given a pipe system say, with three points Q, R, and S where forces act, induced forces at R and at S (due to a force causing motion at Q), can be eliminated by adding the appropriate forces at R (a force at R induces forces at Q and at S) and at S (a force at S induces forces at Q and at R). Only one force will then remain acting on the pipe, a force causing motion at Q.

6. Find moments throughout the line resulting from the force causing motion (say, at Q) by adding (a) moments due to the force causing motion at Q, plus (b) moments due to the force causing motion (to remove induced force) at R, plus (c) moments due to the force causing motion (to remove induced force) at S.

Example 1. A 4-inch schedule 40 pipe, material A.S.T.M. A-106 Grade B, having fixed ends, runs east 5′-0″, north 5′-0″, then east 25′-0″. Elbows are long radius. Determine moments throughout the line, and the value of maximum stress, resulting from expansion

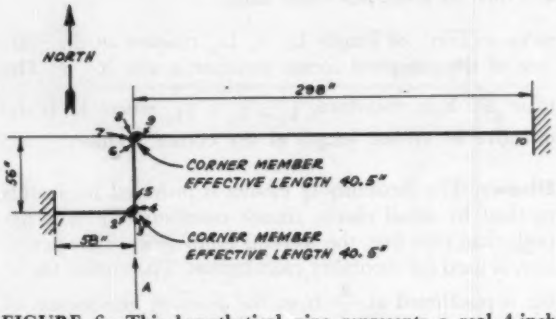

FIGURE 6—This hypothetical pipe represents a real 4-inch pipe in Example 1.

About the Author

J. S. Moloney is a senior engineer for Polymer Corp., Ltd., Sarnia, Ont., where he supervises design and drafting work in the Maintenance Department, Engineering Division. He has a B.A.S. degree in mechanical engineering from the University of Toronto, and a masters degree in engineering from University College, Dublin, Ireland. With Polymer six years, Moloney has previous experience with National Research Council, Ottawa; Cockshutt Industries, Ltd., and Gas Dynamics Laboratory, McGill University. He is a member of the Engineering Institute of Canada and the Association of Professional Engineers, Ontario.

when temperature goes from 70 to 400 F. Use the Code for Pressure Piping[4] for values of elastic modulus, coefficient of thermal expansion, flexibility factor k, and stress intensification factor i.

Solution. Figure 6 shows the hypothetical line to be used for the Example 1. The steps in the procedure are recorded in Table 1. Each column refers to a similarly numbered point in Figure 6.

Stiffness ratios for the four moment balancing steps necessary appear in lines 1, 2, 3 and 4 of Table 1. The fixed-end moments calculated from thermal expansion appear in line 5. These are balanced in lines 6, 7, 8 and 9, with resulting moments appearing in line 10. Calculation of shear forces (see line 11) shows that an unbalanced force of 987 pounds must act southward on the pipe to account for the moments shown in line 10. This force has to be removed by a force *causing motion* acting in the opposite direction.

Fixed-end moments due to a 1-pound force causing motion applied at A in Figure 6, appear in line 14. These are then balanced—lines 15, 16, 17 and 18. A force of .397 pound acting northward and causing motion results at A. Moments due to a 987-pound force causing motion are then determined (line 12), and added to those of line 10 to give final bending moments throughout the pipe line (line 13).

The maximum bending moment occurs at an elbow. Therefore, as noted in the Code for Pressure Piping, the maximum bending stress is equal to $\frac{iM}{Z}$, or $\frac{1.92 \times 29000}{3.214} = 17330$ pounds per square inch; (Z is section modulus for pipe cross-section).

Example 2. A 14-inch line, wall thickness .500 inches, material A.S.T.M. A106 Grade A, runs from a fixed end horizontally eastward 24′-3″, southward 19′-3″ and downward 46′-0″ to a fixed-end. Elbows are long radius. Temperature goes from 70 F. to 600 F. Determine the bending moments due to thermal expansion, again using the Code for Pressure Piping for material constants.

Solution. Figure 7 shows the hypothetical line to be used in this example. Steps in the procedure are recorded in Table 2. Each column refers to a similarly numbered point in Figure 7. Stiffness ratios appear in

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	STIFFNESS RATIOS	STEP 1						+.500	+.500	+.500		.343	+.500	.172	.333	+.500			
2		" 2	+.500	.500			.588	.042	.041	.282	.292	.708	+.500	-.086	+.066	.660			
3	DISTRIBUTION FACTOR	" 3	+.800	.595	.405	.500	.594	.041	.041	.718				-.086	+.046	.502	.498	.498	.502
4	CARRY OVER FACTOR																		
5	FIXED END MOMENTS × $\frac{1}{EIR^2}$		-.088	-.088					-2126	-2126			+304	+304					
6	DISTRIBUTION OF MOMENTS (FOR MOMENT BALANCING)	STEP 1							+1197				+625	+313					
7		" 2	+222	+444		+444	+18	-18	+329	+659	+271	-271	-658	-329					
8		" 3	+132	+264	+180	-180	-264	-11	+11										
9	TOTALLED MOMENTS (SHEAR FORCES UNBALANCED)		-634	-180	+180	-180	+180	+7	-7	-1198	-271	+271	+271	+258					
10	SHEAR FORCES (LBS.)		2515 LBS. ↓			861 LBS. →				5165 LBS. ↓			1025 LBS. →						
11	MOMENTS ADDED TO CORRECT FOR UNBALANCED SHEAR FORCES		-25.2	-80.4	+80.4	-80.4	+35.6	-80.6	+6.9	+14.2	-14.2	+14.2	-14.2	-14.0					
12			+197.5	+134.0	-134.0	+134.0	-5.9	+6.9							-4.3	+4.3	+59.0	+59.0	+59.0
13									+736.0	+134.3	-134.3	+134.3	-134.3	-67.1	-165.0	+165.0	+218.8	-218.8	-218.8
14	FINAL MOMENTS (SHEAR FORCES BALANCED)		-161.7	-54.4	+54.4	-54.4	+54.4	+21.7	-21.7	-455.1	-122.5	-122.5	+122.5	+176.9	-169.3	+169.3	+272.8	-272.8	-272.8
15	FIXED END MOMENT (DUE TO 1 LB. AT A)						-102.1	-102.1					+16.2	+16.2					
16	DISTRIBUTION OF MOMENTS (FOR MOMENT BALANCING)	STEP 1				+47.9	+35.8	+6.3	-5.3	-10.6			-5.6	-3.8					
17		" 2	+13.6	+27.1		+27.1	+1.1	+1.1	+3.8	+7.5	+3.1	-3.1	-7.5	-3.8					
18		" 3	-8.1	-16.1	-11.0	+11.0	+6.7	-0.7											
19	TOTALLED MOMENTS		+5.5	+11.0	-11.0	+11.0	-4.5	+6.5	-1.5	-3.1	+3.1	-3.1	+3.1	+3.8					
20	SHEAR FORCES (LBS.)		.0351 LBS. ↓			.0716 LBS. →				.0162 LBS. ↓			.0233 LBS. →						
21	SAME AS LINES 14-19 EXCEPT 1 LB. AT B		-124.3	-134.3											+1.6	-1.5	-22.3		
22			+3.1	+62.15		+62.15	+2.6	-2.6							-0.7	+0.7	+11.2	+11.1	-11.1
23			+16.5	+37.0	+25.2	-25.2	-37.0	-1.5	+1.5						+0.8	-0.8	-11.1	-11.1	-11.2
24			-74.7	-25.2	+25.2	-25.2	+25.2	+1.1	-1.1										
25			.1518 LBS. ↓			.1212 LBS. ←										.0549 LBS. ←			.0615 LBS. ↓
26	SAME AS LINES 14-19 EXCEPT 1 LB. AT C								-49.8	-49.8					-75.0	-75.0			
27									+14.4	+28.8					+7.7	+67.3	+88.7		
28									+5.3	+10.6	+4.4	-4.4	-10.6	-5.3	-1.8	+1.8	+27.3	+14.8	+7.0
29															-0.5	+0.5	+7.0	-7.0	-3.5
30									-24.1	-4.4	+4.4	-4.4	+4.4	+2.2	+5.4	-5.4	-7.0	+7.0	+3.5
31									.1009 LBS. ↓				.0121 LBS. →		.0571 LBS. ←			.0199 LBS. ↓	

TABLE 2—Steps in the Procedure for Example 2.

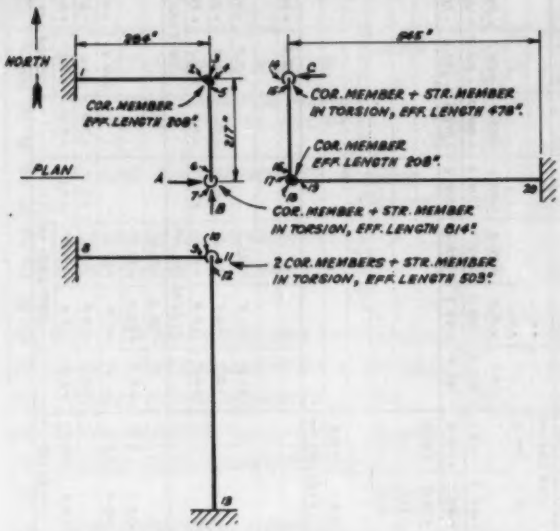
NORTH
324"
245"
PLAN
COR. MEMBER EFF. LENGTH 208"
COR. MEMBER + STR. MEMBER IN TORSION, EFF. LENGTH 478"
COR. MEMBER EFF. LENGTH 208"
COR. MEMBER + STR. MEMBER IN TORSION, EFF. LENGTH 814"
2 COR. MEMBERS + STR. MEMBER IN TORSION, EFF. LENGTH 503"

FIGURE 7—This hypothetical pipe represents a real 14-inch pipe in Example 2.

lines 1, 2, and 3, and fixed-end moments, calculated from thermal expansion, in line 4. These are balanced in lines 5, 6, and 7, resulting moments appearing in line 8.

The unbalanced shear forces (line 9) may be considered to act as indicated by arrows in Figure 7. Unbalanced shear forces (equal to +164 pounds at A, +2,515 pounds at B, and +5,165 pounds at C, Figure 7), must be eliminated by the addition of moments throughout the pipe line resulting from forces of equal magnitude and direction but opposite sense, applied at those points and causing motion.

In order to find the moments caused by such forces, fixed-end moments due to a force causing motion of 1 pound applied first at A (line 14), next at B (line 20), and next at C (line 26) are determined. Final moments caused by these applied forces, after balancing, appear in lines 18, 24, and 30, and corresponding shear forces in lines 19, 25 and 31 respectively. These resulting unbalanced shear forces are summarized in Table 3, in which the figures in bold type are forces causing motion, and those not in bold type are induced forces.

Induced forces at B and C, line 19, Tables 2 and 3, may be eliminated by addition of x times the force causing motion at B, line 25, plus y times the force causing motion at C, line 31, where x and y are such that forces at B and C, line 19, become zero. Thus:

$$\frac{-.0581 + .4133x}{+.0161 + .0548x} = \frac{+.0193}{+.1574}$$

$$\therefore x = +.148$$

and

$$+.0162 + .148 \times (+.0548) + .1574\,y = 0$$

$$\therefore y = -.154$$

In the same way, induced forces in lines 25 and 31 are also eliminated. It should be noted that the addition of a set (or multiple of a set) of shear forces shown in line 19 (or line 25, or line 31) Table 3, to the pipe line, automatically means that the moments shown in line 18 (or line 24 or line 30 respectively), occur also in the pipe line.

TABLE 3—Summary of Shear Forces (Circled Numbers Refer to Lines of Table 2)

⑲ **+.0947 A**	**−.0581 B**	**+.0162 C**
㉕ **−.1212 A**	**+.4133 B**	**+.0548 C**
㉛ **+.0121 A**	**+.0193 B**	**+.1574 C**

The moments that have to be added to eliminate induced forces in lines 19, 25, and 31 of Tables 2 and 3, and also those necessary to eliminate the unbalanced shear forces in line 9 of Table 2, are shown by means of the following summary: (For circled numbers in this summary read "moments in similarly numbered lines in Table 2".)

(a) $+1 \times ⑱ + .148 \times ㉔ - .154 \times ㉚$ cause + .074 lb. at A, 0 lb. at B and 0 lb. at C

$\therefore -2190 \times ⑧ - 324 \times ⑭ + 336 \times ㉖$ cause −164 lbs. at A

(b) $+1 \times ⑱ + 1.342 \times ㉔ - .486 \times ㉚$ cause + .3259 lb. at B, 0 lb. at A and 0 lb. at C

$\therefore -10290 \times ⑧ - 7715 \times ⑭ + 3750 \times ㉖$ cause −2515 lbs. at B

(c) $+1 \times ⑱ - .2285 \times ㉔ - .0788 \times ㉚$ cause + .1494 lb. at C, 0 lb. at A and 0 lb. at B

$\therefore +7900 \times ⑱ + 2725 \times ㉔ - 34600 \times ㉚$ cause −5165 lbs. at C

This summary shows that moments appearing in line 18 of Table 2, multiplied by −4580 (which is the sum of −2190, −10290, +7900), have to be added to those of line 8, Table 2, because of the unbalanced shear forces which appear in line 9, (equal to 164 lbs. at A, 2,515 pounds at B and 5,165 pounds at C, Figure 7, respectively). The summary shows also that lines 24 and 30 of Table 2 have to be multiplied by −5,314 and −30,514 respectively, and added to line 8. Such added moments appear in lines 10, 11, and 12 of Table 2, to give the final moments, which appear in line 13.

Examination of Table 2 shows that the maximum bending moment occurs at the upper end of the pipe. Moments at this point are 455,100 inch-pounds in the south elevation view, and 161,700 inch-pounds in the plan view. The maximum resulting bending moment is, therefore, $\sqrt{455100^2 + 161700^2} = 482500$ inch-pounds. Torsion equal to 169,300 inch-pounds (line 13, column 14, Table 2), occurs in the pipe at the same point.

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[2] Southwell, R. V. "Stress-Calculation in Frameworks by the Method of Systematic Relaxation of Constraints." Proceedings of the Royal Society of London, Vol. 153, p. 41, 1935.

[3] Urquhart, L. C. "Civil Enginering Handbook," published by McGraw-Hill Book Company Inc., New York, Toronto, London.

[4] "Code for Pressure Piping," A.S.A. B31. 1-1955, published by The American Society of Mechanical Engineers, Note also new code published May, 1959.

Here is a powerful tool for handling multi-component distillation with a digital computer. It has proven its ability to figure the conventional splitter as well as the special cases of multi-feed and side-streams.

The authors are continuing to develop this new method for other special cases such as absorbers and strippers. When they perfect these techniques, they will prepare additional reports for the PETROLEUM REFINER. Look for Part 4 in an early issue.

Digital computer used to . . .

Figure Distillation This New Way

Part 1—New Convergence Method Will Handle Many Cases
Part 2—Product Purity Can Set Conditions for Column
Part 3—Consider Multi-Feed Columns With Side-Streams

W. N. Lyster
Humble Oil & Refining Company, Baytown, Texas

S. L. Sullivan, Jr., D. S. Billingsley and C. D. Holland
A&M College of Texas, College Station

THE CONVERGENCE method[17] given in Parts 1 and 2 for conventional columns is extended here to include complex columns having any number of feed plates and side-streams. The stepwise calculations through the column are effected by the method proposed by Thiele and Geddes.[18] In order to illustrate the application of this method, a column having two feed plates and two side-streams (in addition to the top and bottom products) is treated in detail. The only assumption made in the proposed calculational procedure is that of perfect plates.

In the application of the method of Thiele and Geddes to complex columns, one specifies the column pressure, the number of plates, the rate, composition and thermal condition of each feed as well as the locations of the feed plates and the side-streams. The number of additional specifications which may be made is equal to the total number of streams withdrawn (the distillate, bottoms and side-streams). For a column containing two side-streams, the additional specifications L_o (or V_1), D, W_1 and W_2 may be made. These in turn fix the dependent variable B. (The symbols used here are identi-

fied near the end of Part 1 with additions made near the end of this part.)

In order to make the first trial, temperature and L/V profiles for the column are assumed. As shown in a subsequent section, this allows one to carry out plate-to-plate calculations down from the top and up from the bottom of the column, giving the l_{j1}/d_i's and l_{j1}/b_i's, respectively. Requiring a match at one of the feed plates leads to b_i/d_i for each component.

After applying the convergence method described in Part 1, the compositions and corresponding temperatures as well as the molal rates of flow of all streams are calculated. This calculational procedure is repeated until satisfactory agreement between the assumed and calculated temperature profiles is obtained. The development of the convergence method follows.

METHOD OF CONVERGENCE

In order to illustrate the concepts involved, the development of the equations which constitute the convergence method for the case of the withdrawal of a single side-stream from the rectifying section of the column is given. For this example the specifications are taken to be V_1, D (or B) and W_1.

A given stepwise calculation through the column by use of the method of Thiele and Geddes,[18] described in a subsequent section, leads to a set of calculated values for the b_i/d_i's and $w_{1\ i}/d_i$'s from which the corresponding sets of values of the d_i's, b_i's and w_{1i}'s are obtained by component material balance. For example, the calculated values of the d_i's are obtained by solving the following expression for $(d_i)_{ca}$.

$$FX_{Fi} = (d_i)_{ca}\left(1 + (b_i/d_i)_{ca} + (w_{1i}/d_i)_{ca}\right) \quad (45)$$

Although each $(d_i)_{ca}$ is in material balance, the sum of these d_i's is not necessarily equal to the specified value of D. The corrected d_i's are those which are both in material balance and in agreement with the specifications and which are to be used in the calculation of the composition of the vapor and liquid streams throughout the column. The composition of the liquid leaving plate j is calculated as follows:

$$x_{ji} = \frac{(l_{ji}/d_i)_{ca}\,(d_i)_{co}}{\sum_{i=1}^{c}(l_{ji}/d_i)_{ca}\,(d_i)_{co}} \quad (46)$$

Similarly, the mole fraction of component i in the bottoms is given by:

$$(x_{Bi})_{co} = \frac{(b_i/d_i)_{ca}\,(d_i)_{co}}{\sum_{i=1}^{c}(b_i/d_i)_{ca}\,(d_i)_{co}} \quad (47)$$

The subscript "co" is used in order to emphasize the fact that it is inferred in the definition of the corrected d_i's that the mole fractions calculated by Equation (47) give the corresponding $(b_i)_{co}$'s when multiplied by the specified value of B. When this operation is performed, Equation (47) becomes

$$(b_i/d_i)_{co} = \Theta_o\ (b_i/d_i)_{ca} \quad (48)$$

where,

$$\Theta_o = \frac{B}{\sum_{i=1}^{c}(b_i/d_i)_{ca}\,(d_i)_{co}} \quad (49)$$

The corrected set of d_i's also fixes the composition of the side-stream W_1. It is to be recalled that the composition of a liquid side-stream is the same as that of the liquid on the plate from which it is withdrawn. Thus, the corrected composition of the side-stream is given by

$$(x_{w1i})_{co} = \frac{(w_{1i}/d_i)ca\ (d_i)_{co}}{\sum_{i=1}^{c}(w_{1i}/d_i)_{ca}\,(d_i)_{co}} \quad (50)$$

Again the corrected molal rates are given by multiplying both sides of Equation (50) by W_1. Thus,

$$(w_{1i}/d_i)_{co} = \Theta_1\,(w_{1i}/d_i)_{ca} \quad (51)$$

where,

$$\Theta_1 = \frac{W_1}{\sum_{i=1}^{c}(w_{1i}/d_i)_{ca}\,(d_i)_{co}} \quad (52)$$

An expression for $(d_i)_{co}$ is now readily obtained. A material balance for component i gives

$$FX_{Fi} = (d_i)_{co} + (b_i)_{co} + (w_{1i})_{co}$$

or,

$$FX_{Fi} = (d_i)_{co}[1 + (b_i/d_i)_{co} + (w_{1i}/d_i)_{co}]$$

Upon substitution of the relationships given by Equations (48) and (51) into the above expression, one finds

$$(d_i)_{co} = \frac{FX_{Fi}}{1 + \Theta_o\,(b_i/d_i)_{ca} + \Theta_1\,(w_{1i}/d_i)_{ca}} \quad (53)$$

Furthermore, since these d_i's are also in agreement with the specifications,

$$\sum_{i=1}^{c}(d_i)_{co} = D \quad (54)$$

A corrected set of d_i's have been determined when a set of Θ's is found which satisfies simultaneously Equations (49), (52) and (53). It is to be noted that when the expression for $(d_i)_{co}$, Equation (53), is substituted in Equations (49) and (52), two independent equations containing the two unknowns Θ_o and Θ_1 are obtained.

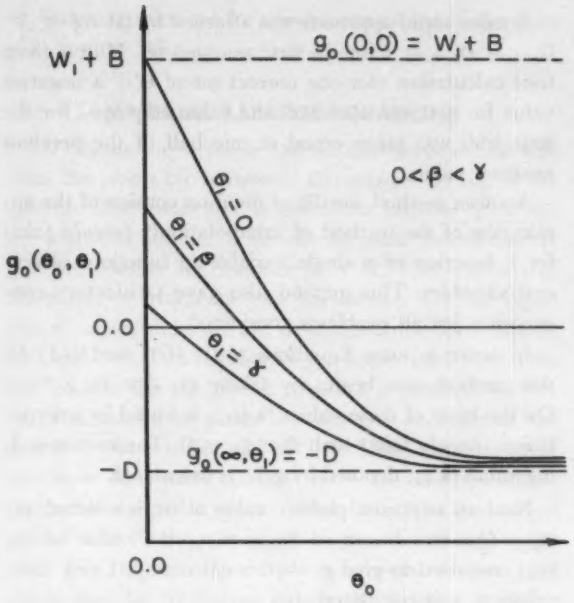

FIGURE 9—For the case of one side-stream, a graphical representation of the function $g_0(\Theta_0,\Theta_1)$ shows the influence of both Θ_0 and Θ_1.

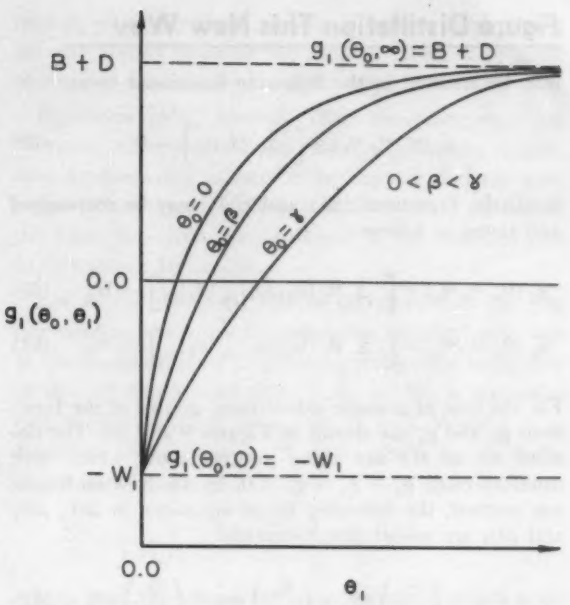

FIGURE 10—Here is a graphical representation of the other function $g_1(\Theta_0,\Theta_1)$. The desired set of Θ's are those which give simultaneously $g_1 = g_0 = 0$.

Also, instead of Equations (49) and (52), one could solve Equations (52) and (54). Methods for solving these equations are discussed in a following section.

Generalization for Any Number of Side-Streams. Suppose that in addition to the side-stream W_1 of the rectifying section, a second side-stream W_2 is withdrawn from the stripping section. Further, suppose that V_1, D (or B), W_1 and W_2 are specified. Generally, it is convenient to calculate the composition of the liquid leaving the j^{th} plate in the stripping section by

$$x_{j1} = \frac{(l_{j1}/b_1)_{ca}\,(b_1)_{co}}{\sum_{i=1}^{c}(l_{j1}/b_1)_{ca}\,(b_1)_{co}} \qquad (55)$$

In the same manner as shown previously for Θ_1, an expression for Θ_2 in terms of $(b_1)_{co}$ is readily obtained by use of Equation (55). However, in order to retain the symmetry and ease of application of the equations it is preferable to define Θ_2 in terms of $(d_1)_{co}$. Since $(w_{21}/b_1)_{ca}\,(b_1/d_1)_{ca} = (w_{21}/d_1)_{ca}$, Equation (46) may be used for the calculation of the composition of the side-stream W_2. It is easily shown that Equations (46) and (55) give identical sets of compositions. Then, in the same manner as shown previously,

$$(w_{21}/d_1)_{co} = \Theta_2\,(w_{21}/d_1)_{ca} \qquad (56)$$

where,

$$\Theta_2 = \frac{W_2}{\sum_{i=1}^{c}(w_{21}/d_i)_{ca}\,(d_i)_{co}} \qquad (57)$$

The expression for $(d_1)_{co}$ becomes

$$(d_1)_{co} = \frac{FX_{Fi}}{1 + \Theta_0\left(\frac{b_1}{d_1}\right)_{ca} + \Theta_1\left(\frac{w_{11}}{d_1}\right)_{ca} + \Theta_2\left(\frac{w_{21}}{d_1}\right)_{ca}} \qquad (58)$$

Additional side-streams are treated in the same manner. Also, it might be remarked that Equation (58) is applicable for a column containing any number of feed plates since FX_{Fi} is the total moles of component i entering the column in all of the feeds.

Calculation of the Θ's. Two methods described most frequently in the literature for the solution of non-linear equations are (1) iteration and (2) the Newton-Raphson method. Among others, Nielsen[19] has discussed these methods. When the expression for $(d_1)_{co}$, Equation (58), is substituted in Equations (49), (52) and (57), three independent equations in the variables Θ_0, Θ_1 and Θ_2 are obtained which are in the desired form for the application of the method of iteration.

This method gives the desired set of Θ's provided the criterion for convergence as stated by Nielsen is satisfied. Problems were encountered where these conditions were not satisfied and this method is not in general recommended.

On the other hand, convergence was always obtained with the Newton-Raphson method, although this method involves more calculations per trial than the method of iteration. In the Newton-Raphson method, the most convenient set of functions is obtained by a slight rearrangement of Equations (52), (54) and (57). Equation (54)

may be restated in the following functional form.

$$g_o(\Theta_o, \Theta_1, \Theta_2) = \left[\sum_{i=1}^{c} (d_i)_{co}\right] - D \qquad (59)$$

Similarly, Equations (52) and (57) may be rearranged and stated as follows:

$$g_1(\Theta_o, \Theta_1, \Theta_2) = \left[\sum_{i=1}^{c} \Theta_1 (w_{1i}/d_i)_{ca} (d_i)_{co}\right] - W_1 \qquad (60)$$

$$g_2(\Theta_o, \Theta_1, \Theta_2) = \left[\sum_{i=1}^{c} \Theta_2 (w_{2i}/d_i)_{ca} (d_i)_{co}\right] - W_2 \qquad (61)$$

For the case of a single side-stream, graphs of the functions g_o and g_1 are shown in Figures 9 and 10. The desired set of Θ's are those positive roots which give simultaneously $g_o = g_1 = g_2 = 0$. In the Newton-Raphson method, the following linear equations in $\Delta\Theta_o$, $\Delta\Theta_1$ and $\Delta\Theta_2$ are solved simultaneously.

$$0 = g_o + \left(\frac{\partial g_o}{\partial \Theta_o}\right)\Delta\Theta_o + \left(\frac{\partial g_o}{\partial \Theta_1}\right)\Delta\Theta_1 + \left(\frac{\partial g_o}{\partial \Theta_2}\right)\Delta\Theta_2 \qquad (62)$$

$$0 = g_1 + \left(\frac{\partial g_1}{\partial \Theta_o}\right)\Delta\Theta_o + \left(\frac{\partial g_1}{\partial \Theta_1}\right)\Delta\Theta_1 + \left(\frac{\partial g_1}{\partial \Theta_2}\right)\Delta\Theta_2 \qquad (63)$$

$$0 = g_2 + \left(\frac{\partial g_2}{\partial \Theta_o}\right)\Delta\Theta_o + \left(\frac{\partial g_2}{\partial \Theta_1}\right)\Delta\Theta_1 + \left(\frac{\partial g_2}{\partial \Theta_2}\right)\Delta\Theta_2 \qquad (64)$$

where,

$$\Delta\Theta_o = \Theta_{o,2} - \Theta_{o,1}$$

$$\Delta\Theta_1 = \Theta_{1,2} - \Theta_{1,1}$$

$$\Delta\Theta_2 = \Theta_{2,2} - \Theta_{2,1}$$

The second subscripts 1 and 2 denote the assumed and calculated values of the Θ's, respectively. Analytical expressions for the partial derivatives are readily obtained. For example,

$$\frac{\partial g_o}{\partial \Theta_o} = \sum_{i=1}^{c} \frac{\partial (d_i)_{co}}{\partial \Theta_o} = -\sum_{i=1}^{c} \frac{(b_i/d_i)_{ca} (d_i)^2_{co}}{FX_{Fi}}$$

The functions g_o, g_1, g_2 and their derivatives appearing in Equations (62), (63) and (64) are evaluated at $\Theta_o = \Theta_{o,1}$, $\Theta_1 = \Theta_{1,1}$ and $\Theta_2 = \Theta_{2,1}$. After these equations have been solved for $\Delta\Theta_o$, $\Delta\Theta_1$ and $\Delta\Theta_2$, the set of Θ's to be assumed for the next trial are computed as follows:

$$\Theta_{o,2} = \Theta_{o,1} + \Delta\Theta_o$$

$$\Theta_{1,2} = \Theta_{1,1} + \Delta\Theta_1$$

$$\Theta_{2,2} = \Theta_{2,1} + \Delta\Theta_2$$

When the first assumed set of Θ's was taken to be $\Theta_{o,1} = \Theta_{1,1} = \Theta_{2,1} = 0$, positive values for the $\Delta\Theta$'s were always calculated in the process of convergence to the desired set of Θ's.

A more rapid approach was afforded by taking $\Theta_{o,1} = \Theta_{1,1} = \Theta_{2,1} = 1$ for the first assumed set. If in a given trial calculation (for the correct set of Θ's) a negative value for a Θ was obtained, the value employed for the next trial was taken equal to one half of the previous assumed value.

Another method worthy of mention consists of the application of the method of interpolation[16] *(regula falsi)* for a function of a single variable to functions of several variables. This method also gave satisfactory convergence for all problems considered.

In order to solve Equations (59), (60) and (61) by this method, one begins by taking $\Theta_{o,1} = \Theta_{1,1} = 1$. On the basis of these values, a $\Theta_{2,1}$ is found by interpolation *(regula falsi)* such that $g_2 = 0$. The corresponding value of g_1, denoted by $g_{1,1}$, is calculated.

Next an arbitrary, positive value of Θ_1, is selected, say $\Theta_{1,2}$. On the basis of $\Theta_{o,1}$, $\Theta_{1,2}$, the value of Θ_2, $\Theta_{2,2}$, required to give $g_2 = 0$ is calculated. Using these values $g_{1,2}$ is calculated.

The value of Θ_1 to be employed for the next trial, $\Theta_{1,3}$, is calculated by the interpolation formula as follows:

$$\Theta_{1,3} = \frac{g_{1,2}\Theta_{1,1} - g_{1,1}\Theta_{1,2}}{g_{1,2} - g_{1,1}}$$

The procedure is repeated until a pair of values for Θ_1 and Θ_2 is found such that $g_1 = g_2 = 0$, for $\Theta_o = 1.0$. The corresponding value of g_o is computed.

Then a second arbitrary, positive value for Θ_o is selected, $\Theta_{o,2}$, and the above procedure repeated, after which g_o is again computed. The next best value for Θ_o is computed by the interpolation formula as shown previously for Θ_1.

Repeated application leads to the desired set of Θ's, provided any negative values obtained for the Θ's in the calculational procedure are replaced by positive values, say one-half of the last positive value assumed for the particular Θ.

Other Types of Specifications. As shown in Part 2 for conventional columns, the convergence method is readily extended to include various types of specifications. For example, if instead of specifying the total distillate rate, D, the sum of the d's for the first s components, $\sum_{i=1}^{s} d_i$, is made, Equation (59) becomes

$$g_o = \sum_{i=1}^{s} (d_i)_{co} - \sum_{i=1}^{s} d_i$$

When similar specifications are made on the side-streams, the corresponding equations are modified accordingly. Equation (58) is used in the calculation of the d for each of the c components. However, because of the numerous impossible specifications which may be made, it is perhaps best to solve a particular problem

by obtaining solutions for various sets of specified values of D and the W's.

MATERIAL BALANCE EQUATIONS

To discuss the stepwise calculations through the column, the plates are numbered down from the top of the column. The condenser is given the number zero, the top plate the number 1, the bottom plate the number N and the reboiler the number N + 1. The numbers of the plates at which the two side-streams (in the liquid phase) are withdrawn are designated, for convenience, "p" and "q". The number of the upper feed plate (the one nearest the top of the column) is denoted by "f", and the number of plates between and exclusive of the two feed plates is denoted by "n". Thus, the number of the lower feed plate is "f + n + 1." The symbol F_1 represents the molal rate at which the upper feed enters plate f, and F_2 the rate at which the second feed enters plate f + n + 1. The n plates between the two feed plates may be treated as either rectifying or stripping plates. In the present treatment they are taken to be in the stripping section. The rectifying section includes the condenser and plates j = 1 through j = f — 1, and the stripping section contains plates j = f through j = N as well as the reboiler. In the rectifying section each material balance includes a given plate and the condenser; whereas, in the stripping section, each balance includes a given plate and the reboiler.

Rectifying Section. The material balances for the rectifying section are as follows:

$$\frac{v_{1i}}{d_i} = A_{oi} + 1, \text{ (balance around the condenser)} \qquad (65a)$$

$$\frac{v_{ji}}{d_i} = A_{j-1,i}\left(\frac{v_{j-1,i}}{d_i}\right) + 1, 2 \leqq j \leqq p+1 \qquad (65b)$$

$$\frac{v_{ji}}{d_i} = A_{j-1,i}\left(\frac{v_{j-1,i}}{d_i}\right) + C_{1i}, p+2 \leqq j \leqq q+1 \qquad (65c)$$

$$\frac{v_{ji}}{d_i} = A_{j-1,i}\left(\frac{v_{j-1,i}}{d_i}\right) + C_{2i}, q+2 \leqq j \leqq f-1 \qquad (65d)$$

$$\frac{\bar{v}_{fi}}{d_i} = A_{f-1,i}\left(\frac{v_{f-1,i}}{d_i}\right) + C_{2i} \qquad (65e)$$

where,

$A_{oi} = L_o/K_{oi}\,D$, for a partial condenser; for a total condenser $A_{oi} = L_o/D$.

$A_{ji} = L_j/K_{ji}\,V_j$; relates v_{ji} and l_{ji} as follows: $l_{ji} = A_{ji}\,v_{ji}$.

$C_{1i} = 1 + w_{1i}/d_i$ and $C_{2i} = C_{1i} + w_{2i}/d_i$.

$\bar{v}_{fi}$ = molal rate at which component i (in the vapor) enters plate f — 1. The quantities V_j and L_j appearing in the expression for A_{ji} are defined as the total molal rates at which vapor and liquid, respectively, leave plate j. It is to be observed that the total molal rates at which the vapor and liquid streams leave plate j are not always equal to the rates at which they enter plates j — 1 and j + 1, respectively.

Equations (65a) through (65e) represent recursion formulas, since each of the ratios, w_{1i}/d_i and w_{2i}/d_i, may be evaluated as needed in the calculational procedure. Equations for the calculations of w_{2i}/d_i are of the same form and are developed in the same manner as that shown for w_{1i}/d_i.

Let W_1 be the molal rate of withdrawal of the first side-stream, which has a composition identical with that of the liquid on plate p. Since L_p is the total molal rate of flow of liquid from plate p, $L_p - W_1$ is the molal rate of flow of liquid onto plate p + 1. When j = p, Equation (65b) gives v_{pi}/d_i from which w_{1i}/d_i is obtained as follows:

$$\frac{w_{1i}}{d_i} = \left(\frac{W_1}{L_p}\right)\left(\frac{l_{pi}}{d_i}\right) = \left(\frac{W_1}{L_p}\right)\left(A_{pi}\,\frac{v_{pi}}{d_i}\right)$$

where l_{pi} is the total molal rate of flow at which component i (in the liquid phase) leaves plate p. Use of this value of w_{1i}/d_i permits the calculation of C_{1i} and application of Equation (65c). After v_{qi}/d_i has been evaluated, w_{2i}/d_i is calculated in a manner analogous to that shown for w_{1i}/d_i. This procedure is continued until the first feed plate is reached. When a side-stream is withdrawn as a vapor, the treatment is similar to that shown for liquids. Obviously, the calculational procedure described for two side-streams is readily extended to columns having any number of side-streams.

After the equations for the rectifying section have been applied, calculations are commenced at the reboiler and continued upward to the top feed plate, plate f, which is taken to be in the stripping section.

Stripping Section. The material balance equations for the stripping section are as follows:

$$\frac{l_{Ni}}{b_i} = S_{N+1,\,i} + 1, \text{ (balance around the reboiler)} \qquad (66a)$$

$$\frac{l_{j-1,i}}{b_i} = S_{ji}\left(\frac{l_{ji}}{b_i}\right) + 1, f+n+2 \leqq j \leqq N \qquad (66b)$$

$$\frac{l_{f+n,i}}{b_i} = S_{f+n+1,i}\left(\frac{l_{f+n+1,i}}{b_i}\right) + \left(1 - \frac{l_{F2i}}{b_i}\right) \qquad (66c)$$

$$\frac{l_{j-1,i}}{b_i} = S_{ji}\left(\frac{l_{ji}}{b_i}\right) + \left(1 - \frac{F_2 X_{F2i}}{b_i}\right), f+1 \leqq j \leqq f+n \qquad (66d)$$

$$\frac{l_{f-1,i}}{b_i} = S_{fi}\left(\frac{l_{fi}}{b_i}\right) + \left(1 - \frac{F_2 X_{F2i}}{b_i} - \frac{l_{F1i}}{b_i}\right) \qquad (66e)$$

where,

$S_{ji} = \dfrac{K_{ji}\,V_j}{L_j}$, which relates v_{ji} and l_{ji} as follows: $v_{ji} = S_{ji}\,l_{ji}$.

When a vapor or liquid side-stream is withdrawn in the stripping section, Equation (66) is modified accordingly. The calculations are initiated by application of Equation

(66a). The second, Equation (66b), represents a recursion formula. Continued application of it leads to a value for $v_{f+n+1,1}/b_1$. Before Equation (66c) may be applied, it is necessary to know each of the b's. Each b_i is calculated from the expression for b_i/d_i, derived in the following manner. When the expression of l_{f+n}/b_i, Equation (66c), is substituted in Equation (66d) (with $j = f + n$), one obtains

$$\frac{lf+n-1,\,i}{b_i} = S_{f+n,i}\left(\frac{v_{f+n+1,i}}{b_i}\right) + S_{f+n,i}\left(1 - \frac{lF2i}{b_i}\right) + \left(1 - \frac{F_2X_{F2i}}{b_i}\right) \qquad (67)$$

A continuation of this substitutional process leads to the expression for the liquid rate of component i leaving plate f — 1, the plate above the top feed plate.

$$\frac{l_{f-1,i}}{b_i} = \phi_i\left(\frac{v_{f+n+1,i}}{b_i}\right) + \phi_i\left(1 - \frac{l_{F2i}}{b_i}\right) + \Phi_i\left(1 - \frac{F_2X_{F2i}}{b_i}\right) - \frac{l_{F1i}}{b_i} \qquad (68)$$

where,

$$\phi_i = S_{fi}\,S_{f+1,\,i}\cdots\cdots S_{f+n-1,\,i}\,S_{f+n,\,i}$$

$$\Phi_i = S_{fi}\,S_{f+1,\,i}\cdots\cdots S_{f+n-2,\,i}\,S_{f+n-1,\,i} + S_{fi}\,S_{f+1,\,i}\cdots\cdots S_{f+n-3,\,i}\,S_{f+n-2,\,i} + \cdots + S_{fi}\,S_{f+1,\,i} + S_{fi} + 1$$

The numerical values of the ratios $l_{f-1,i}/d_i$ and $v_{f+n+1,i}/b_i$ are calculated by application of Equations (65d) and (66b) for the rectifying and stripping sections, respectively. When stated in terms of these quantities, Equation (68) takes the form

$$\left(\frac{l_{f-1,i}}{d_i}\right)\left(\frac{d_i}{b_i}\right) = \phi_i\left(\frac{v_{f+n+1,\,i}}{b_i}\right) + \phi_i + \Phi_i - \frac{1}{b_i}\left[\phi_i\,l_{F2i} + \Phi_i\,F_2\,X_{F2i} + l_{F1i}\right] \qquad (69)$$

An expression for b_i in terms of b_i/d_i is obtained by making an overall material balance

$$b_i = \frac{(b_i/d_i)\,FX_{Fi}}{C_{2i} + (b_i/d_i)} \text{ or } d_i = \frac{FX_{Fi}}{C_{2i} + (b_i/d_i)} \qquad (70)$$

where,

$$FX_{Fi} = F_1X_{F1i} + F_2X_{F2i}$$
$$F = F_1 + F_2$$

When the above expression for b_i is substituted in Equation (69), one obtains the following matching equation.

$$\left(\frac{b_i}{d_i}\right) = \frac{\left(\frac{l_{f-1,\,i}}{d_i}\right) + C_{2i}\,Z_i}{\phi_i\left[\left(\frac{v_{f+n+1,\,i}}{b_i}\right) + 1\right] + \Phi_i - Z_i} \qquad (71)$$

where,

$$Z_i = \frac{\phi_i\,l_{F2i} + \Phi_i\,F_2\,X_{F2i} + l_{F1i}}{FX_{Fi}}$$

This expression is valid for feeds of any thermal condition. When the thermal condition of feed F_1 is either boiling point or subcooled liquid, $l_{F1i} = F_1X_{F1i}$ and when it is dew point or superheated vapor $l_{F1i} = 0$. Analogous relations for l_{F2i} may be stated for the feed F_2. After b_i/d_i has been evaluated by use of Equation (71), the value of b for each component is readily calculated by use of Equation (70). This value of b permits calculations indicated by Equation (66) to be performed.

When "R" side-streams are withdrawn above the upper feed plate and "P" are withdrawn below the lower feed plate, the following expression for (b_i/d_i) is obtained.

$$\left(\frac{b_i}{d_i}\right) = \frac{\left(\frac{l_{f-1,\,i}}{d_i}\right) + C_{Ri}\,Z_i}{\phi_i\left[\left(\frac{v_{f+n+1\,,i}}{b_i}\right) + C_{Pi}\right] + \Phi_i - C_{Pi}\,Z_i} \qquad (72)$$

where,

$$C_{R1} = 1 + \frac{W_{1i}}{d_i} + \frac{W_{2i}}{d_i} + \cdots\cdots + \frac{W_{Ri}}{d_i}$$

$$C_{Pi} = 1 + \frac{W_{R+1,\,i}}{b_i} + \frac{W_{R+2,\,i}}{b_i} + \cdots\cdots + \frac{W_{R+P,\,i}}{b_i}$$

The equations describing columns having three or more feeds are developed in a manner similar to that

TABLE 15—Statement of Examples

FEED	F_1X_{F2}	F_2X_{F2}
C H_4	2.0	0.0
C_2H_6	10.0	0.0
C_3H_8	6.0	1.0
C_3H_8	12.0	7.0
i-C_4	1.0	4.0
n-C_4	3.0	17.0
C_5	0.5	15.2
C_6	0.0	9.0
C_7	0.0	4.5
C_8	0.0	4.3
360	0.0	3.5
Total	34.5	65.5

EXAMPLE NO.	STREAM RATES			
	Distillate D	Vapor, V_1	Side-Stream[1], W_1	Side-Stream[2], W_2
1	38.0	94.8	0.0	0.0
2	23.0	94.8	15.0	0.0
3	23.0	94.8	15.0	25.0

[1] Side-Stream W_1 withdrawn as Liquid from plate No. 3.
[2] Side-Stream W_2 withdrawn as Vapor from plate No. 15.

Other Conditions for Examples 1, 2, 3.
Thermal condition of feed F_1 = Dew Point Vapor.
Thermal condition of feed F_2 = Bubble Point Liquid.
Feed F_1 to enter on plate No. 7.
Feed F_2 to enter on plate No. 12.
Total number of plates = 19.
Operating pressure = 264.7 (psia).
Type of condenser = partial.

TABLE 16—Equilibrium and Enthalpy Data

COMPONENT	a_1	a_2	a_3	c_1	c_2	c_3	e_1	e_2	e_3
CH_4	63.76528	−29.51969	4.25794	1840.25	1345.33	−11.110	4864.17	773.26	19.0294
C_2H_6	10.93719	− 3.88431	0.55580	3147.12	2222.47	10.935	8483.48	1280.67	65.9954
C_3H_8	4.03335	− 1.14742	0.17389	4213.82	2874.12	40.076	11254.87	1746.81	102.5564
C_4H_{10}	3.64797	− 1.06505	0.16197	4425.16	2968.64	48.868	11806.71	1797.38	112.6239
i-C_4	1.46077	− 0.18097	0.02721	5320.76	3525.03	90.076	13726.02	2261.20	167.3186
n-C_4	1.00000	0.00000	0.00000	5553.24	3641.27	90.076	14851.06	2312.00	155.9965
C_5	0.17185	0.22019	−0.02826	6663.21	4161.81	160.848	18757.52	2903.45	233.0578
C_6	0.00541	0.14775	−0.01056	7661.13	4658.30	231.661	20445.36	3207.59	287.9913
C_7	−0.02141	0.07538	0.00061	8676.69	5066.88	310.574	23038.41	3713.28	328.7941
C_8	−0.01184	0.02524	0.00593	9845.04	5353.77	403.497	25539.97	4119.20	405.9716
360	−0.00145	− 0.00053	0.00430	11509.74	6023.85	599.071	30246.89	5121.06	524.2676

$$K \text{ (for n—C}_4\text{)} = -0.04195 + 0.34087\left(\frac{T}{100}\right) - 0.01815\left(\frac{T}{100}\right)^2 + 0.02872\left(\frac{T}{100}\right)^3, \text{ T in °F}$$

$$a_i = a_{1i} + a_{2i}\left(\frac{T}{100}\right) + a_{3i}\left(\frac{T}{100}\right)^2, \text{ T in °F.}$$

$$h_i = c_{1i} + c_{2i}\left(\frac{T}{100}\right) + c_{3i}\left(\frac{T}{100}\right)^2, \text{ T in °F.}$$

$$H_i = e_{1i} + e_{2i}\left(\frac{T}{100}\right) + e_{3i}\left(\frac{T}{100}\right)^2, \text{ T in °F.}$$

Equilibrium data taken from Reference [13].
Enthalpy data taken from Reference [10].

TABLE 17—Temperature Profiles and Distillate Rates for Example 1

PLATE NUMBER	Initial Profile, °F	TEMPERATURE, °F, AT TRIAL NUMBER GIVEN							
		1	2	3	4	5	10	11	12
0 (Distillate)	80.0	92.12	92.59	93.12	93.69	93.89	94.47	94.50	94.53
1	98.5	104.38	105.38	106.50	107.70	108.10	109.26	109.32	109.39
2	117.0	110.11	112.03	113.99	115.95	116.54	118.21	118.29	118.38
3	135.5	113.98	117.73	120.87	123.72	124.42	126.45	126.51	126.62
4	154.0	116.34	123.30	127.94	131.64	132.32	134.37	134.39	134.49
5	172.5	116.46	128.68	134.89	139.30	139.70	141.49	141.45	141.55
6	191.0	113.93	134.34	141.59	146.53	146.31	147.64	147.53	147.63
7 (Feed F_1)	209.5	137.62	155.48	163.06	169.01	169.80	172.67	172.63	172.76
8	228.0	147.91	165.77	174.43	181.41	182.90	186.51	186.49	186.62
9	246.5	151.79	171.45	182.03	190.24	192.33	196.37	196.33	196.46
10	265.0	151.41	175.00	188.67	198.55	201.20	205.53	205.45	205.57
11	283.5	148.07	180.58	199.34	211.56	214.37	218.53	218.37	218.50
12 (Feed F_2)	302.0	143.41	208.58	235.39	248.31	247.94	249.45	249.01	249.26
13	320.5	157.92	212.51	236.66	248.88	249.44	250.89	250.63	250.72
14	339.0	175.89	219.07	239.51	250.34	251.40	252.61	252.51	252.50
15	357.5	195.20	227.43	243.67	252.62	253.75	254.72	254.68	254.63
16	376.0	213.75	236.41	248.54	255.45	256.50	257.22	257.20	257.15
17	394.5	231.04	245.66	254.03	258.78	259.83	260.31	260.29	260.24
18	413.0	248.23	255.94	260.78	263.56	264.38	264.61	264.59	264.56
19	431.5	267.82	269.57	271.06	272.06	272.45	272.39	272.38	272.35
20 (Reboiler)	450.0	295.94	295.38	294.89	294.42	294.34	294.05	294.04	294.03
Calculated value of D	.....	54.7	33.4	36.0	36.6	37.8	38.019	37.979	38.010
Θ_0	....	275.56	0.14	0.38	0.53	0.91	1.009	0.990	1.005

shown for a column having two feeds and any number of side streams. Also, when side-streams are located between the two feed plates, the same general approach is employed.

ENTHALPY BALANCES

Enthalpies of the vapor and liquid streams leaving plate j are calculated in the usual manner

$$H_j = \sum_{i=1}^{c} H_{ji}\, y_{ji} \qquad \text{(vapor)} \qquad (73)$$

$$h_j = \sum_{i=1}^{c} h_{ji}\, x_{ii} \qquad \text{(liquid)} \qquad (74)$$

where, H_{ji} and h_{ji} are the enthalpies of the pure component i in the vapor and liquid states, respectively, at the temperature of plate j.

The enthalpy balance equations which were employed are similar in form to those stated in Part 1.

TABLE 18—Solution of Example 2

Trial Number	Θ_0	Θ_1	Temp. of D, °F	Temp. of W_1, °F	Temp. of B, °F	Calculated Value of D	Calculated Value of W_1
1	489.45	1.54	77.31	101.78	295.26	27.48	31.80
2	0.16	0.94	77.17	103.84	293.99	20.18	11.49
3	0.36	0.96	77.08	105.03	293.49	21.80	13.36
4	0.50	0.97	77.03	105.89	293.13	22.22	13.87
5	0.788	0.991	77.01	106.18	293.17	22.78	14.34
6	0.846	0.993	76.99	106.41	293.14	22.84	14.75
7	0.951	0.997	77.00	106.51	293.17	22.95	14.93
8	0.943	0.996	76.99	106.62	293.13	22.94	14.92
9	0.983	0.998	76.98	106.69	293.11	22.97	14.99
10	0.976	0.997	76.98	106.75	293.08	22.97	14.97
11	0.992	0.999	76.98	106.79	293.06	22.99	14.998

ILLUSTRATIVE EXAMPLES

The statements and solutions of three illustrative examples are given in Tables 15 through 20. Example 1 has two feeds while Example 2 has in addition a side-stream withdrawn from the rectifying section of the column. Example 3 has two feeds and two side-streams, one withdrawn from each section of the column. The same general calculational procedure, described in Part

TABLE 19—Solution of Example 3

TRIAL NUMBER	Θ_0	Θ_1	Θ_2	Temp. of D, °F	Temp. of W_1, °F	Temp. of W_2, °F	Temp. of B, °F	Calculated Value of D	Calculated Value of W_1	Calculated Value of W_2
1	156.78	1.30	7.84	77.64	114.40	238.07	354.72	26.78	23.39	31.96
2	0.47	1.08	0.61	77.46	112.48	253.54	250.39	22.88	13.00	24.69
3	0.64	1.04	0.76	77.34	111.52	262.87	347.12	22.94	13.84	24.54
4	0.78	1.02	0.85	77.27	111.06	267.20	345.45	22.95	14.31	24.84
5	0.93	1.01	0.96	77.22	110.74	268.56	344.96	23.04	14.73	23.42
6	0.94	1.01	0.96	77.19	110.60	269.16	344.73	23.00	14.81	24.04
7	0.980	1.004	0.988	77.17	110.52	269.34	344.67	23.01	14.93	25.01
8	0.984	1.002	0.986	77.16	110.50	269.41	344.63	23.00	15.22	25.04
9	1.000	1.000	1.000	77.15	110.48	269.40	344.60	23.00	14.98	25.01

TABLE 20—Final Flow Rates

COMPONENT	EXAMPLE 1	EXAMPLE 2		EXAMPLE 3		
	d_i	d_i	W_{1i}	d_i	W_{1i}	W_{2i}
CH_4	$0.2000X10$	$0.1973X10$	$0.2653X10^{-1}$	$0.1974X10$	$0.2612X10^{-1}$	$0.1950X10^{-10}$
C_2H_6	$0.1000X10^{2}$	$0.9079X10$	0.9207	$0.9106X10$	0.8937	$0.2136X10^{-4}$
C_3H_8	$0.6930X10$	$0.3758X10$	$0.3150X10$	$0.3782X10$	$0.3000X10$	0.2163
C_4H_{10}	$0.1795X10^{2}$	$0.8135X10$	$0.9554X10$	$0.8048X10$	$0.8931X10$	$0.1994X10$
i-C_4	0.7398	$0.3961X10^{-1}$	0.6545	$0.6284X10^{-1}$	0.9640	$0.3333X10$
n-C_4	0.3810	$0.1478X10^{-1}$	0.6917	$0.2687X10^{-1}$	$0.1159X10$	$0.1354X10^{2}$
C_5	$0.4181X10^{-4}$	$0.1152X10^{-5}$	$0.3168X10^{-2}$	$0.2083X10^{-5}$	$0.5130X10^{-2}$	$0.4365X10$
C_6	$0.1025X10^{-9}$	$0.9654X10^{-12}$	$0.1248X10^{-6}$	$0.3728X10^{-11}$	$0.4194X10^{-6}$	$0.1121X10$
C_7	$0.2126X10^{-14}$	$0.1021X10^{-16}$	$0.7047X10^{-10}$	$0.5243X10^{-16}$	$0.3049X10^{-9}$	0.2826
C_8	$0.1983X10^{-19}$	$0.1283X10^{-21}$	$0.6586X10^{-13}$	$0.2865X10^{-20}$	$0.1200X10^{-11}$	0.1350
360	$0.3311X10^{-25}$	$0.4096X10^{-28}$	$0.1956X10^{-15}$	$0.1274X10^{-26}$	$0.4476X10^{-14}$	$0.2989X10^{-1}$

1, was employed in the solution of the examples.

It should be mentioned that no particular effort was made to select good initial values for the temperatures and vapor rates. For all examples a linear variation of the temperature profile (80 and 450°F) was assumed in order to make the first trial; see Table 17. An overhead vapor rate, $V_1 = 94.8$, was specified for all examples. For the first two trials, the remaining vapor rates throughout the column were held constant either at this value or at the appropriate one obtained by taking into account the thermal condition of each feed and each side-stream. Corresponding to these vapor rates, the liquid rates employed were those required for material balance. After the first two trials, the vapor and liquid rates were calculated by enthalpy balances as described in Part 1 under "Forcing Procedures". Also, each calculated temperature profile after the first was averaged with the one used to make the particular trial calculation. The profiles shown in the tables were obtained in this manner. The forcing procedures stated in Part 1 were employed in the solution of the illustrative examples as well as other complex columns and found to give satisfactory results. For the large scale computer, the time required to solve an example is essentially the same as that stated previously in Parts 1 and 2.

It is to be noted that the Θ-method gives very nearly the correct temperatures of the distillate and bottoms after about the first two or three trials. Thus, the corresponding compositions of the distillate and bottoms are nearly correct. Due to the nature of the calculational procedure, an accumulation of errors is obtained as the feed plates are approached, which results in slower convergence for this part of the column. In view of this, the temperatures of the side-streams did not converge quite as rapidly as those of the distillate and bottoms. Because of the ease of application and the rapidity of convergence of problems solved by the Θ-method, it is believed that this method will be very helpful to those who wish to make multicomponent distillation calculations.

SYMBOLS USED
(See also Part 1)

C —Used in the material balance equations and defined with Equation 65.

n —Number of plates between and exclusive of the two feed plates.

w —Molal rate of flow of component i in the side-streams.

W —Total molal flow rate of side-stream.

Z —A sum of terms as defined with Equation 71.

Subscripts

f —Upper feed plate when more than one feed plate exists.

p —Upper side-stream.

P —Number of side-streams below the lower feed plate.

q —Lower side-stream.

R —Number of side-streams above the upper feed plate.

LITERATURE CITED
(See also Part 1)

[19] Nielson, K. L., "Methods in Numerical Analysis," the Macmillan Company, New York, 201-211 (1956).

ACKNOWLEDGMENT

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TO BE CONTINUED

New Equation Correlates MVP and RVP

An empirical correlation equation has been developed for converting micro vapor pressures (MVP) to the numerical level of the familiar Reid method

A. Y. Mottlau
Esso Research and Engineering Company
Linden, New Jersey

A CORRELATION equation of high accuracy has resulted from an extensive program comparing micro vapor pressure (MVP) and Reid vapor pressure (RVP) test results. The program involved the cooperation of seven petroleum laboratories. Anyone using the micro method may use this equation with confidence to convert their MVP results to the numerical level of the familiar RVP method.

Previously[1] it was pointed out that a straight line correlation exists between results obtained by the MVP and the Reid[2] methods, and an empirical correlation equation was presented. The exactness of this equation was somewhat suspect, since it was based on a small amount of data from only one laboratory. In view of the broadening interest in the method, the results of a cooperative program designed, primarily, to establish a firm correlation between the results obtained by the two procedures are presented.

PROGRAM DESIGN

Seven laboratories participated in the program. They consisted of four research and three refinery laboratories located both in the United States and in Europe.

Test Samples. Identical sets of twenty samples, described in Table 1, were submitted to each laboratory for test.

TABLE 1—Description of Samples

Fuel No.	Type	Average RVP	No. Samples Per Lab.
1	Gasoline	14.1	4
2	Gasoline	6.3	4
3	Gasoline	9.9	4
4	Jet Fuel	2.9	4
5	Cyclopentane	9.7	2
6	Methylcyclopentane	4.5	2

Three gasolines and a jet fuel were submitted in quadruplicate and two pure compounds in duplicate. Their vapor pressures were well distributed over the range from 3 to 14 pounds Reid. None of the fuels contained alcohol. Erroneous results are obtained by the standard "wet" Reid method when alcohol-containing blends are measured.

Test Procedure and Apparatus. The cooperators followed a standard procedure for MVP and reported the difference between the initial and

TABLE 2—Test Results

Lab. No.: Sample No.	1		2		3		4		5		6		7	
	MVP[1]	RVP[2]	MVP	RVP	MVP	RVP	MVP	RVP	MVP	RVP	MVP	RVP	MVP	RVP
1	802	14.1	812	14.49	(789)[3]	..	805	14.1	802	14.05	834	14.0	802	13.87
	812	14.3	815	14.14	(793)	..	811	14.2	799	14.10	810	14.0	812	14.14
	806	14.2	803	13.63	(631)	..	801	14.0	806	14.10	783	14.1	806	13.68
	800	14.2	804	13.85	(808)	..	804	14.1	806	14.10	794	14.3	806	13.73
Average	805	14.2	808	14.1	....	..	805	14.1	803	14.1	805	14.1	808	13.8
2	373	6.3	381	6.60	374	..	373	6.5	373	6.25	369	6.2	375	6.09
	371	6.2	374	6.27	376	..	375	6.3	371	6.45	375	6.4	373	6.23
	372	6.3	374	6.09	386	..	375	6.3	373	6.25	376	6.3	372	6.37
	370	6.6	376	6.21	384	..	374	6.4	371	6.40	372	6.2	375	6.12
Average	372	6.4	376	6.3	380	..	374	6.4	372	6.3	373	6.3	374	6.2
3	574	9.8	592	10.02	571	..	576	10.1	576	10.05	567	9.7	570	9.76
	571	10.0	579	9.71	586	..	576	9.8	568	9.95	586	9.9	573	9.80
	568	9.5	578	9.77	565	..	573	10.0	574	9.90	578	9.9	571	9.79
	577	10.1	582	9.73	595	..	574	10.0	572	9.90	573	10.0	570	9.90
Average	572	9.8	583	9.8	579	..	575	10.0	572	10.0	576	9.9	571	9.8
4	185	3.1	183	2.69	184	..	186	2.8	185	3.00	176	2.6	185	2.72
	184	2.9	183	2.55	183	..	188	2.8	182	3.00	184	2.8	184	2.85
	182	3.0	187	2.73	189	..	187	2.9	185	3.00	184	2.9	185	2.86
	183	2.9	183	2.80	185	..	187	2.9	185	3.00	185	2.9	185	2.88
Average	184	3.0	184	2.7	185	..	187	2.8	184	3.0	182	2.8	185	2.8
5	547	10.0	550	9.50	549	..	556	10.0	553	9.80	552	9.7	548	9.78
	547	9.9	548	9.55	549	..	551	9.6	554	9.90	550	9.2	552	9.84
Average	547	10.0	549	9.5	549	..	553	9.8	554	9.8	551	9.4	550	9.8
6	275	4.5	273	4.58	275	..	278	4.6	274	4.55	275	4.2	272	4.53
	274	4.6	274	4.66	273	..	276	4.5	276	4.45	286	4.6	277	4.55
Average	275	4.6	274	4.6	274	..	277	4.6	275	4.5	280	4.4	274	4.5

[1] MVP as mm. of Hg and including dissolved air.
[2] Pounds Reid.
[3] Samples opened several times; not included in calculations.

final manometer readings in millimeters of mercury and all were equipped with essentially identical MVP instruments manufactured commercially. RVP results were obtained by ASTM Method D323-56 and reported as "pounds Reid."

Test Results returned are given in Table 2. Lab #3 submitted only MVP results, having abandoned the RVP method. Their measurements could not, of course, be included in the correlation calculations but were used in the precision study.

Correlation Equation. The equation correlating MVP (in millimeters of mercury, uncorrected for air) with RVP (in pounds per square inch) was calculated by the method of least squares.

$$RVP = 0.0180\ (MVP) - 0.43$$

At the 95 percent confidence level, the deviation of the slope is:

$$2\,S_s = 0.00016$$

and of the intercept,

$$2\,S_i = 0.04$$

These standard deviations signify an error in the correlation equation so small that it does not lend itself to graphical representation. The "error envelope" which is customarily drawn on either side of the regression line to mark the limits of that line's possible location would, in this case, be almost entirely obscured by the thickness of the regression line itself.

The slopes and intercepts of the equations for the data of the individual laboratories are given in Table 3. Also included is the coefficient of determination (r^2) and the standard deviation (S) of the points around the regression line for each case. The coefficient of determination, or the square of the correlation coefficient, is defined as the sum of squares due to regression over the total sum of squares, i.e.,

$$r^2 = \frac{b^2 \Sigma (x - \bar{x})^2}{\Sigma (y - \bar{y})^2}$$

where

$$b = \frac{\Sigma (x - \bar{x})(y - \bar{y})}{\Sigma (x - \bar{x})^2}$$

It is a relative measure of the goodness of fit of the points to the regression line. An $r^2 = 1$ would imply a perfect correlation. In these cases, $r^2 = 0.997$ or better, implying excellent correlations. (S) tells the same story in more practical terms. It says that 68 percent of the points fall within about 0.2 pounds Reid of the regression line.

TABLE 3—Correlation of MVP With RVP

Laboratory No.	Slope (# Reid/ mm. Hg.)	Intercept (# Reid)	r^2	S (# Reid)
1	0.0181	−0.36	0.9977	0.20
2	0.0180	−0.51	0.9975	0.21
4	0.0182	−0.48	0.9990	0.13
5	0.0180	−0.34	0.9994	0.10
6	0.0181	−0.54	0.9967	0.24
7	0.0178	−0.38	0.9978	0.19
Overall	0.0180	−0.43	0.9976	0.30

The agreement among the laboratories on the slope is extremely good, but at first glance, the numerical values of the intercept do not appear to agree very well. It should be remembered, however, that they represent a maximum spread of only 0.2 pounds Reid and a two-sigma of 0.04 pounds Reid, which is quite good. The variation in intercept is probably a reflection of the bias which is known to exist among laboratories running RVP's. The existence of this bias was the prime incentive for carrying out this cooperative program.

Reproducibility. The calculations on reproducibility of results involved seven laboratories for the MVP and six laboratories for the RVP method. Some of the cans containing the more volatile samples were known to have leaked in transit. While these bad "leakers" have not been included in the precision calculations, other "leakers" might not have been noticed. Naturally, such samples would have an adverse effect on precision measurements. Consequently, the reproducibility of measurement of each of the six fuels has been calculated separately, in addition to the over-all reproducibility. The results of these calculations, expressed as one standard deviation, are given in Table 4.

TABLE 4—Reproducibility (S)

Fuel No.	Type	Avg. RVP	Reproducibility (# Reid)	
			MVP	RVP
1	Gasoline	14.1	0.17	0.20
2	Gasoline	6.3	0.07	0.14
3	Gasoline	9.9	0.14	0.15
4	Jet Fuel	2.9	0.05	0.14
5	Cyclopentane	9.7	0.05	0.24
6	Methylcyclopentane	4.5	0.07	0.12
	Average Sigma		0.10	0.16

As might be expected, the two most volatile gasolines gave poorer MVP reproducibility, 0.17 and 0.14, as compared with an average of 0.06 for the other four, comprising two low volatility fuels and two pure compounds. The 0.06 value is believed to be more representative of MVP reproducibility, while the higher values probably reflect small volatility losses. Since these "sample errors" appear to be of a magnitude just sufficient to bring the reproducibility of the MVP results up to the level of the RVP, they would not be expected to affect the reproducibility of the Reid values materially. The over-all reproducibility of the MVP measurements was 0.10 pounds Reid.

Conclusions. Statistical analysis indicates that the equation presented in this paper is an excellent correlation of MVP and RVP. Anyone using the Micro method may use this equation with confidence to convert their MVP results to the numerical level of the familiar RVP method.

The reproducibility of the MVP method is no worse than 0.10 psi. Where differences due to sample weathering can be eliminated, the reproducibility standard deviation may be as small as 0.06 psi.

LITERATURE CITED

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[2] Am. Soc. Testing Materials, Philadelphia, Pa. "ASTM Standards on Petroleum Products and Lubricants," Method D323-56, 1956.

About the Author

A. Y. Mottlau is a senior chemist for Esso Research and Engineering Co., Linden, N. J., where he handles exploratory research in the field of hydrocarbon analysis. Holder of a B.S. degree in chemical engineering from the University of Pittsburgh, he has been with Esso Research for 25 years. Mottlau has publications and/or patents in the fields of petroleum technology, infra-red spectroscopy, electron microscopy, X-ray fluorescence, X-ray absorption and vapor pressure measurement.

How to Manage an Engineering Project

Check these hints if you want to be a good project engineer

- **Have good engineering specs. or it will cost you an extra 10-15 percent**
- **Have clear definition of scope of work or be prepared for many extras**
- **Delegate authority and cut the red tape**
- **Don't try to settle arguments by mail, get agreement by personal contact**

John F. McGarry
University of California
Berkeley

SUCCESS OR FAILURE of a process construction job depends largely on good project management. The responsibility of this management lies with the project engineer. This article details that responsibility.

The operating company's project engineer on a large process construction job, or project manager or coordinator, as he is variously called, is considered to be responsible for working with others for the purpose of achieving a safe, operable plant, one which comes on stream promptly on schedule at full production and at the designed efficiency and catalyst life.

The scope of people with whom the project engineer will work will therefore be broad indeed and will include management, process designers, pilot plant engineers, operating staff, contractor's engineers, draftsmen, accountants, buyers, expediters, inspectors, contract people, estimators, the field engineering, inspection and construction crew, the equipment suppliers, and public relations men.

The following is presented in order to discuss certain of the more important aspects of his relations in functions with such associates in the engineering design in order that the plant can be designed and built with speed, without excessive cost, and with good quality of design and workmanship.

The First Step. Upon the completion of the process design and receipt of comments by the operating personnel, the engineering design can be carried forward by the project engineer for the operating company to the point where preliminary engineering design specifications and standards are assembled, to allow the project to be put out for competitive bids by contractors.

Final Plant Objectives. The primary objective can be speed of completion, economy of construction, or quality of design and workmanship. Usually it is a combination of varying shades of each. But let it be clearly borne in mind that these are conflicting goals. A high quality plant cannot be built fast and cheaply.

An attempt to accomplish the three objectives simultaneously is hopeless and destructive of morale. Management should recognize this problem and use their mature judgment to determine just what priority each objective should receive.

The Contract Type. Rase and Barrow[1] present, in their book on Project Engineering, a condensed discussion of the various types of contracts. The McCulloughs,[2] in their two volumes on engineering law, present a comprehensive study of the subject. These will not be duplicated here although some of the writer's supplemental views will be presented.

There seems little question which type of contract is preferred as regards economical construction—one which, wherever possible, is used in lieu of the cost-plus-fixed-fee contract, cost-plus-fixed-fee with guaranteed maximum and division of savings contract, and also preferred over the negotiated fixed-price contract (no competitive bids). One reason for this may be that, if a contractor has both a fixed-price job and a cost-plus job going simultaneously, his most qualified men will probably end up on the fixed-price job.

Regarding the fixed-price contract, reference is also made to the article by J. E. Ross of the Dow Chemical Co.[3] wherein it is stated in no uncertain terms that "Twelve years of experience show the best efficiency with lump sum contracts." And yet, you cannot get quality engineering and construction in a competitive bid project unless your process and engineering design specifications are truly "frozen" and unless your organization has devoted considerable time in keeping its engineering standards comprehensive, up-to-date, and nonconflicting. If this is not the case, you will probably be plagued with expenses for changes and extras to the extent that a cost-plus-fixed-fee contract (or one with guaranteed top and division of savings) might have worked out more economically.

Working for extended periods under cost-plus-fixed-fee or percentage-fee contracts generally seems to end up with friction between the operating company and the contractor. Five instances of this, with four different contractors and four different operating companies, can be recalled.

Some contractors prefer to sell a negotiated fixed price contract to their clients with the suggestion that this form of contract will speed up the job by eliminating the time for getting competitive bids, particularly where

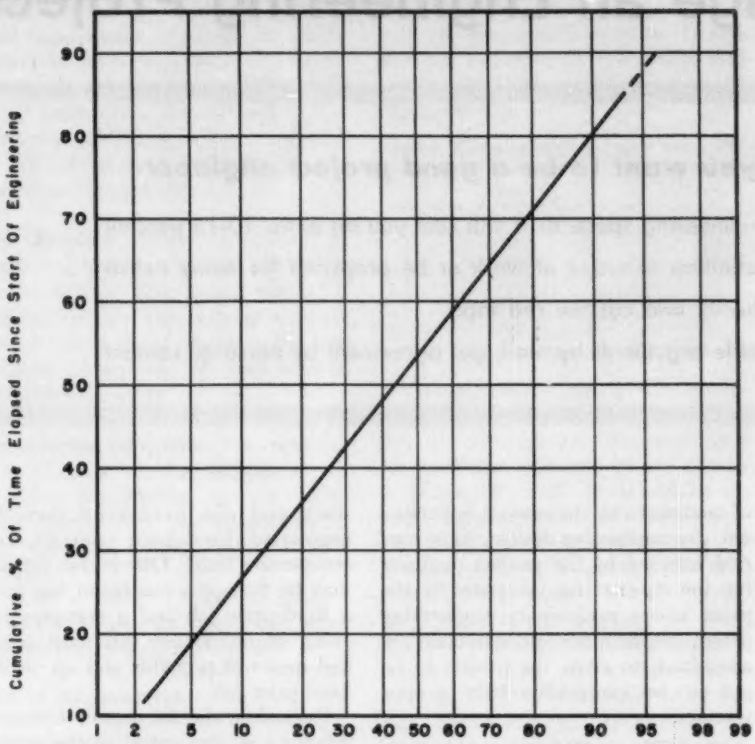

FIGURE 1—Progress payments on a fixed price job can be estimated easily.

the client's engineering design is not far advanced. The engineering design and materials procurement are allowed to proceed for four to six months on a cost-plus-percentage fee basis until all prices for major equipment have been received, whereupon the contractor is able to estimate the job's cost. While this method is reported to possess an advantage, the absence of any competition makes it appear dubious as to whether or not it has any real advantage over competitive bids.

In addition, the advantages as regards engineering and construction time are often exaggerated. Your company will not save the three months or so it takes to get competitive bids because the major part of that time is required in any event to prepare the engineering flowsheet, the plot plan, the process equipment bid specifications, and to obtain and analyze bids on the process equipment. The time actually saved will be comprised primarily of the extra week or two that it takes the contractor to estimate your job plus the several weeks you would have otherwise required for analysis of competitive bids. If there is insufficient time to allow the contractor to get competitive bids on equipment, you can have him bid the job for a fixed price except for reimbursable materials and specific subcontracts.

In the case of the negotiated fixed-price jobs, it is wise to understand in advance just how much control you will really have over the price negotiation. For example, if you see an item for 50,000 feet of pipe, your judgment may tell you about the accuracy of the unit price used, but you will seldom have the time to check the estimate of 50,000 feet. The same would be true of structural steel, excavation, grading, form lumber, concrete, paving, electrical wiring, and many other items. Moreover, even the contractor's unit prices for building up a negotiated fixed-price bid could hardly be expected to be left in your hands for more than a cursory inspection in his presence. His unit prices could be a dangerous weapon against him if they should inadvertently through a careless client fall into the hands of one of his competitors.

Bids. Before you award a job on the basis of a negotiated fixed-price bid, the above points deserve careful consideration. In short, it is felt that operating companies would do well either to maintain a strong enough engineering staff to allow themselves the opportunity of preparing tight engineering specifications and standards, and thereby permitting the use of competitive bids for each project, or alternatively, to hire an outside engineering firm (other than a bidding firm) to prepare such specifications and obtain bids from others.

It should be added that each bid is expensive indeed to the contractor, and hence the number of bidders should be limited so that each has a fair chance of success. If you don't limit the number of bidders, undoubtedly the extra bidding expenses of our country's contractors will eventually be reflected in your construction costs.

It is, of course, grossly unfair to include among the list of bidders (for either the plant, or for its equipment) any bidder who might not, when the bids are in, be considered sufficiently well qualified to do the job.

For obvious reasons, one never has the same contractor do work both on a cost-plus job and on a fixed-price job at the same time, in the same plant, or in the same office. If there appears on the horizon any likely overrun on the fixed-price job, individuals charging time to the work have a natural tendency to exaggerate their time allocations to the cost-plus job.

Some work is understood to be awarded largely on the basis of reciprocity aspects, or because of particularly cordial relations between company top managements—often regardless of the contractor's ability to do proper design work. One case of this nature can be recalled where, after the operating company's project engineer and purchasing manager had canvassed the country for the few contractors who had the know-how to build a certain type of process, and had succeeded in locating only three, into their offices there came the salesman for a contractor who had no know-how on the process but who promptly announced that their respective bosses had already agreed that they would do the job. The consequent effect on morale can well be imagined. So it is, also in the case of reciprocity deals.

If the contractor plans to learn at your expense, his fee should of course

You can have speed, economy or quality but not all three at once. Get your management to state order of importance

be adjusted downward accordingly.

The typical bid or job proposal received from each bidder should at least cover the following:

What work is to be done?
- a. What facilities—process? storage? utilities? buildings?
- b. Process Design? Engineering? Procurement? Construction?

To what definitive specifications? General Standards?

For what consideration?
- a. Fixed Sum Portion: Define what items it covers. Material escalation method? Labor escalation method?
- b. Reimbursable Portion: Define all reimbursable expenses. Guaranteed Maximum Price? or share in underrun and overrun?

When?
- a. Anticipated date of release of definitive specifications to contractor?
- b. Target completion date?
- c. Bonus for early completion? Penalty for late completion? Both?
- d. Date of definitive estimate?
- e. Statement of engineering manpower availability today.

Specimen Contract Exhibits (including consumable supplies, small tools, rental tools and other expense definitions).

The "definitive specifications" referred to above are in the form of Contractor's Design Specifications Book for all fixed-price jobs. This generally includes at least the following information:

- Scope of the job
- Contractor's Functional Responsibility
- License arrangements
- Process Flow and Description
- Performance Guarantees
  - Process (Yields, Quality, Capacity)
  - Utilities
  - Chemicals and Catalysts
  - Mechanical
- Engineering Flowsheets (Preliminary)
  - Process
  - Utilities
  - Waste Disposal (Including Emergency Relief)
- Location Plan, including Plot Limits and definition of hazardous and non-hazardous areas (in accordance with safe spacing rules)
- Plot Plan
- Detailed Equipment Specifications (for purchase)
- Building Specifications
- General Specifications in Accordance with Operating Company standards
  - Electrical
  - Foundations
  - Piping
  - Structures
  - Insulation
  - Instrumentation
  - Sewers
  - Paving and Grading
  - Fire Protection
  - Safety Facilities
  - Painting
  - Inspection Tolerances
  - Packing Schedule
  - Materials Specifications

The foregoing information is necessary to assure that competitive, fixed price bids will be on a common basis, and is also necessary in any event before the major part of the drafting can move forward.

If the above information is incomplete, the difficulties in your comparison of contractors' bids would assume such major proportions as to force you towards a cost-plus-fixed-fee job (or modification thereof) at increased expense to your company.

If you wish to avoid heavy expenses for extras, allow the bidding contractors adequate time to prepare sound bids. With major plants, this usually amounts to something between two and three months, depending upon how busy are the contractors' engineering staff and how busy are their equipment suppliers who must bid the vessels, exchangers, machinery, etc. to each contractor.

If you desire speed, avoid having each bidder study numerous alternatives by bidding only the base case plus perhaps another case including any improvements that may occur to a particular contractor.

Contract Details. In inviting contractors' bids, you can submit your own proposed form of contract for comments by the bidders, or you can request their submittal of a proposed contract form. From the operating company's standpoint, the first course is perhaps best, provided your legal department knows how to draw up a contract which is to the mutual advantage of both parties.

One of the world's largest oil companies provides excellent, mutually beneficial contracts on the theory that it wishes to keep its contractors healthy financially to bid on its future work. Certain of the small oil and chemical companies occasionally try to get contractors to accept contracts which are entirely one sided.

As is pointed out by Rase and Barrow,[1] contract disagreements are seldom intended to be carried to court. The primary purpose of the contract is to provide a record of the original agreement, because memories are short.

Contract Items. A typical list of the items to be covered in the contract includes the following:

- Work To Be Done; Definitive Specifications
- Contract Price; Escalation; Bonus/Penalty Clauses
- Definition of Reimbursable Cost; Overtime Work Authorization
- Consumable Supplies
- Small Tools
- Rental Tools
- Accounting of Cost
- Terms of Payment and Supporting Documents for Invoices
- Changes and Extra Work (Procedure for, and Charges for)
- Completion and Acceptance
- Guarantees (Process, Chemical, Utilities, Mechanical)
- Inspection by Company; by Contractor
- Termination
- Contractor's Responsibility and Insurance
- Patent Indemnification
- Liens
- Compliance with Laws
- Permits (Responsibility for); Licenses
- Title; Surplus Materials
- Independent Contractor
- Designation of Engineer for Operating Company
- Assignments
- Arbitration

- Notices
- Force Majeure
- Secrecy
- Cleanup
- Acceptability of Workmen
- Interference with other Work
- Remedies
- Contractor Assumes Full Responsibility for Knowledge of Jobsite Conditions.

There should usually be a "ceiling" on the total amount of bonus profits which a contractor can make by early job completion, otherwise he may choose to assign unusually heavy manpower to your job, at the expense of his cost-plus jobs, so as to build up a large bonus payment due him. Your company, however, may not need the plant at such an early date, or you may not at that time have manpower trained and available for its operation.

Similarly, from his standpoint, there should be a "ceiling" on the total penalty for late completion.

Moreover, in contracts involving bonus/penalty clauses, both the direct and indirect effect of strikes against the contractor or its suppliers should be made clear, and there should somewhere be a detailed definition of plant completion because your ideas and those of the contractor may differ appreciably on this point.

Plant Completion Items. One definition of plant completion might, for example, include in addition to the major items the following:

- Welding Completed
- All jobsite scaffolding removed
- Insulation and covering in place
- Hydrostatic tests complete for all equipment and piping
- Valves oriented safely so that projecting stems cannot injure operators
- Access platforms for every elevated valve, blind, relief, orifice, manway, instrument and control valve
- Screwed fittings all tight and leakproof
- Valves, flanges, bolts and gaskets all checked and found to be as per specifications
- Test blinds removed for start-up
- Gage glasses and pressure gages oriented so as to be readily observable by operator
- Sample lines, coolers, bleeders and instruments all draining to safe locations
- Slide plates loose under all hot vessels and exchangers including those which must at any time be steamed out
- Piping spring hangers correctly adjusted
- All rotating equipment checked for proper secureness, alignment, rotation, safety protection, lubrication, and freedom from debris and abrasive or injurious materials
- All equipment checked for grounding and for alignment
- All instruments and electrical circuits checked out
- Instument adjustments (preset)
- Control house pressurizing system working
- All pump and compressor suctions protected with screens
- Debris out of all lines and equipment
- All spray painting completed, and all high temperature paint in place. Sand-blasting finished.
- Stand-by maintenance crews on hand for start-up, including instrument engineers.

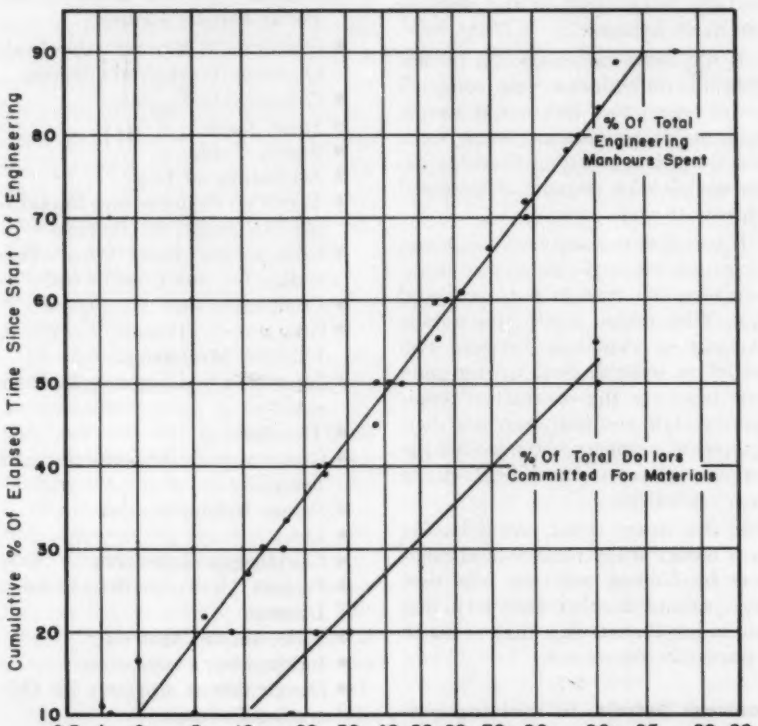

FIGURE 2—Progress payments can also be worked out on a time and material basis.

Reimbursable Costs. If the contract is a cost-plus-fixed-fee job, or if provision is to be made for extra work or changes, a definition of reimbursable cost will always be necessary. This will generally include the following:

- Labor (usually field crew, architects, surveyors, engineers, draftsmen, estimators, buyers, expediters, inspectors)
- Overhead factor to be applied to the above engineers and draftsmen
- Taxes, including sales taxes, payroll taxes and all others except income taxes
- Insurance, including employees' insurance and benefits (specify ins. coverage)
- Independent consultants (expense for, and authorization by whom?)
- Engineering supplies (drafting paper, blueprints and the like)
- Temporary facilities, such as construction buildings
- Telephone expense at the job site, and all L.D. telephone and telegraph expense
- Travel and subsistence for consultants and for contractor's per-

Don't have one contractor, fixed-price and cost-plus jobs going on simultaneously in your plant because the best men will end up on the fixed-price job

sonnel if assigned directly to the job
- Small tools (list agreed-upon charges for)
- Rental tools and construction equipment (list rental rates and who pays maintenance)
- Subcontracts (list what items are to be subcontracted)
- Materials, and their freight to jobsite
- Consumable supplies (list of, e.g. gasoline and lubricating oil for construction equipment).

Agreement should also be reached on fees to be charged for changes and extra work, and for fee reduction for deletion of work.

Regarding "overhead factor" in the above list, reference to Rase & Barrow's book[1] indicates that these generally are billed to you at 100 percent or more. And yet, if a contractor has less than about three dozen typists and payroll girls for an engineering office of 500-700 engineers and draftsmen, it would seem likely that, even including rental of space and desks, and including portions of the salaries of the chief engineer and his assistants, contractor's actual overhead charges will often be well below 100 percent. It should therefore be possible during competitive periods to find contractors who will work for much less than this figure. Also, there should be a definition of personnel so that people who are neither engineering graduates nor draftsmen are not charged to your job at cost plus 100 percent or more, if your contract so stipulates.

To estimate the progress payments due on a fixed price job (engineering, procurement, and construction), a schedule of payments might be worked out by plotting as a straight line the percent of time elapsed since the start of engineering design on a linear scale, against the percent of total contract price payable on a cumulative probability scale. For example, see Figure 1.

Alternatively, the progress payments could be worked out from the typical curves appearing on Figures 2 and 3.

Guarantees for Process, Chemicals and Utilities have been mentioned. Mechanical guarantees are familiar to all. But on a guaranteed maximum price job with division of savings, if changes are required because of poor workmanship, the costs should be charged to the contractor, not to the job.

Inspection of any materials shall be considered your right, but it shall be considered a duty of the contractor.

A clear definition of the contractor's functional responsibilities is of course essential, otherwise you might incur many extras. For example, you should agree in advance who clears the job site, you or the contractor; and who provides temporary utilities during the construction period and where are the points of tie-in for these.

With reference to surplus materials on hand at the conclusion of the work, to whom should these belong, to the contractor or to you? If it is a completely new plant in new territory, you may be able to use these for warehouse stock, inasmuch as some contractors consider them worth only half their original purchase price.

The contract should indicate that the contractor is to obtain from materials suppliers written agreements to hold harmless from patent infringements (or allegations thereof), both the operating company and the contractor, and if the contractor uses materials for which he does not obtain such agreements, then he shall agree to hold the operating company harmless.

Award of the Work. Certain things are important to know before the job is awarded. First of all, the contractor should furnish a list of his experience with similar processes, and the list should be checked with his previous clients if possible to determine if he had startup troubles. For example, your proposed contractor may have built many petroleum processing plants but may never previously have done the process design for a lube oil plant. Or it may have been done

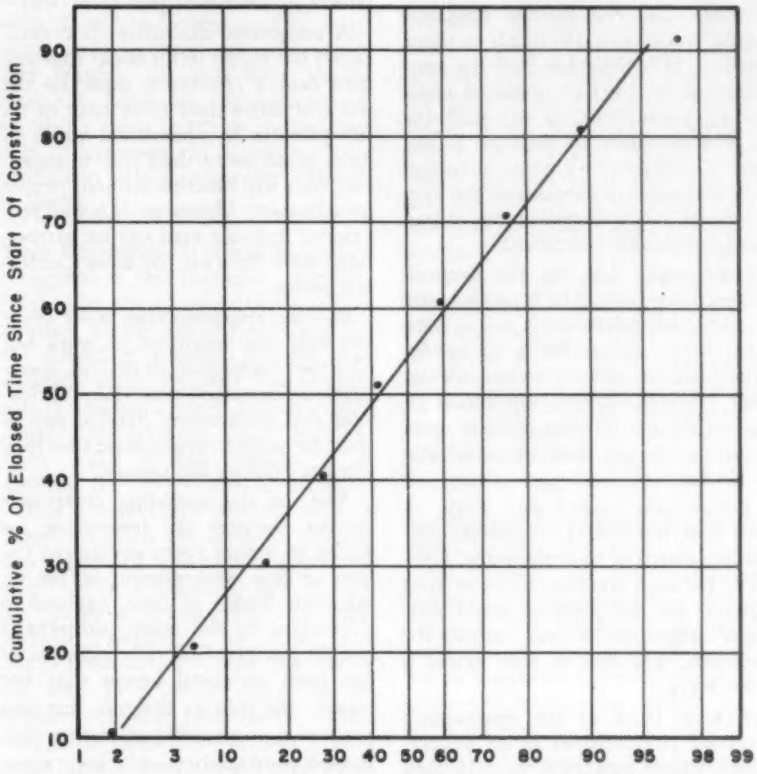

FIGURE 3—Use cumulative percent of total construction manhours spent to find progress payment due.

prior to a recent depression, in which case his manpower with know-how on such processes might have been laid off during the interim. For this reason, you should also obtain a list of the specific process, job engineers, and layout men (and salaries of all), which the contractor agrees to assign to your project, along with the actual experience record of each. Be sure you are getting men with experience and that the contractor is not planning to learn at your expense. It takes more than aggressiveness and intelligence to design a modern complex process—experience is essential.

The contractor's men who will work on your project should preferably be familiar with your engineering standards, otherwise they will have to acquire this knowledge while charging time to your job. Each job engineer should have previous experience with piping drawings. About 60 percent of the typical project is piping drafting and the draftsmen need experienced engineers to supply them with proper design information when it is needed. Moreover, the job engineers should have had actual field construction experience, and the process designers should have been through a plant start-up. It is desirable that the contractor have highly qualified engineering consultants on his staff for his younger men to turn to in the case of compressor and centrifugal filter vibration problems and the like, otherwise you will often have to pay extra for outside consultants.

Contractors' fees for the over-all project vary from 2 to 8 percent, depending upon how busy he is, and upon how anxious he is to handle your plant to secure other similar work. But the actual reputation of the contractor in your field is more important to you than the exact size of his fee.

Before you award any work, be sure that the general specifications and standards of the contractor, especially for such complex items as fired heaters, are adequate to avoid suppliers' attempts to seek extras for omissions. The cost of such extras is often large.

Ask to look at the contractor's standard procedures in all departments which concern you. If they aren't available, perhaps they don't exist. If so, the lack of these may prove costly on any cost-plus-fixed-fee work you may have him do.

Organization. The pace, cost and complexity of a large engineering project are nowadays such as to provide a major challenge to the organizations responsible, both your company and the contractor. Lines of responsibility and authority must be most clearly defined to all concerned and not made vague to accommodate the internal politics of any one company. There is no time for red tape, unwieldy committees and the like. Authority must always be delegated (decentralization) commensurate with responsibility, and divided responsibility is always fatal to success of the venture. But it is dangerous to delegate authority except to those whom you know are properly trained for the job, and who have the proper aptitudes. Crawford Greenewalt, head of duPont and 1959 Gold Medalist of the American Institute of Chemists,[4] states that "an enterprise will succeed only to the extent that all individuals associated with it can be encouraged to exercise their highest talents in their own particular way."

A recognized authority on organization has stated in his book[5] that one man cannot effectively supervise the work of more than from four to six subordinates in nonroutine work. If he is given more than this to supervise, they will function without proper coordination. Moreover, it is well recognized that one man cannot successfully work for two (or more) different bosses.

Specific responsibilities must cover not only the execution of work but also the checking of all designs, specifications, drawings, materials, fabrication and installation. Service groups must be made to understand that they are not "calling the signals."

You, as the operating company's project engineer are responsible for seeing to it that every equipment design or flow arrangement is, for an adequate length of time, exposed to criticism by the most competent people you can find. For example, it has been stressed herein that not merely the process designer but also your own responsible operating personnel, your safety people, your superior, your contractor's most experienced engineers, and the independent consultants, should all contribute their views to the design. Once they have contributed, no unilateral changes are made by yourself or any one else, but instead, in the event a change seems warranted, the views of all are again solicited before any change is actually made.

Your immediate superior has expert knowledge, often on several processes including yours. Discretion must be used, however, in soliciting his know-how because if you ask him merely in order to get a quick answer to a problem, you are avoiding your own responsibility and overloading him. Moreover, he may give you an answer he is not qualified to give and trouble will result in your plant. On the other hand, it would be unwise for you to ignore his ability to contribute substantially to the design. Most engineers have handled this matter quite successfully by bringing problems to their superiors only after they have solutions to submit for their approval. And, of course, your management's approval of major cost alternatives is always necessary.

Project Engineers' Decisions. Thousands upon thousands of decisions and approvals must be made by you (or by your people) within a very short period of time; and it is of the utmost importance that these be made by the most qualified people.

Agreement is always more readily achieved by personal contact than by mail. The mails are useful primarily for transferring information. To use them for settling arguments is unwise, particularly when each letter is signed by a plant or division manager and written by subordinate engineers who have never met.

On the other hand, large meetings are equally useless for arriving at decisions. Subordinates with detailed knowledge will often keep silent if several levels of superiors are represented, particularly to avoid contradicting their superiors. And if managers from competitive plants and divisions are present, the meeting is likely to wind up as an argument between the top men, and the resulting decisions will be determined only by their relative abilities to dominate each other and not by an objective treatment of the technological details by those who have detailed knowledge of them. For this reason, meetings should be kept small.

The project engineer for the operating company can seriously bottle-

Only spot check contractor's and suppliers drawings or they will lean on you for full time checking

neck the entire project unless he is willing to delegate authority to responsible contractor's engineers. He should realize that, once the process design is settled and good engineering standards agreed upon with the contractor, the contractor's engineers are usually in a much better position to carry out the details of engineering design than he, if only because of number. Therefore, he must delegate work to others, or the whole job will bog down.

Nevertheless he must see that they continually check their work and suppliers' drawings by making frequent spot checks on his own part. Sometimes, if overloaded, the contractor tends to lean on the operating company's project engineer to check the contractor's work, or allows him to coordinate contractor's people. Strong efforts should be made to avoid these situations.

All costs must be checked on cost-plus-fixed-fee work. The weekly time distribution sheets must be carefully checked to observe just what classifications of people are charging time to the job, and whether these are in accordance with the contract.

"Gold-plating" should be avoided, and this refers not only to the design itself but also to the design procedure requested from the contractor. For example, the number of copies of drawings should be minimized. So also should the number of isometric study sketches, and perspectives. So should the amount of time and money devoted to fancy progress reports.

It cannot be stressed too heavily that late design changes by your people are usually so costly that their full effects on costs and schedule are rarely imagined. Every possible effort should be made to avoid these unless the plant will not properly operate without their being made.

In doing a cost-plus job, it is wise to continuously watch each draftsman's drawings. If the contractor's office is not fully loaded, you will sometimes find that too much time is being spent in drawing details which are unnecessary to advancement of the job. An example would be putting stairway details on a piping drawing.

Personnel changes, both in your office and among the contractor's project engineers assigned to your job, are costly to the job, once such people have acquired familiarity with your process, your specifications, and standards. In addition they delay the job and increase the chance for errors.

Minimize the repetition frequency on each drawing, specification, data sheet, etc. If a change is made, there is always the likelihood that the change may be overlooked on one of the drawings, resulting then in a fabrication error.

Preliminary Drawings. It is desirable to abolish any required approval by yourself or by the contractor of a supplier's *preliminary detailed* drawings (structural steel, e.g.) because the supplier in such cases merely tends to use yourself or the contractor's engineers to do checking work which he would otherwise do. Suppliers should be made fully responsible for submitting only *final* detailed drawings of materials, such as structural steel for the contractor's review, at its own discretion before shop fabrication begins. On large items, such as structural steel, wherever feasible, the contractor should ordinarily send his engineer to the supplier's shops to review such drawings to minimize the amount of coordination which must be handled by letter.

Your Objective. It would be well to recognize at the beginning, the difference in the primary objectives of yourself as the project engineer for the operating company and the construction superintendent. You are primarily seeking a good, safe, operable plant, fully meeting your specifications. Your second concern is in meeting the target completion date.

The construction superintendent's interest is often primarily in meeting the scheduled completion date and therefore in eliminating any chance for facing a penalty for late completion. Frequently his superiors place construction speed far above all else, even when there is no penalty for late completion. Their viewpoint (logical from their standpoint) is that potential job profits will fade rapidly so long as there is a large construction crew in the field (unless the job is a cost-plus type).

For these reasons, there will be some pressure within the contractor's organization for an early, and sometimes premature, start in the field, and thus for the release of drawings which may not yet be sufficiently checked.

The interest of the construction superintendent is therefore frequently an adverse interest to yours, and it is your duty to see that, regardless opposing interests, the plant is built according to your specifications, and is a safe one to operate.

Inspection. It should be realized that, among some of the newer contractors, the engineering division is often considered merely as a service group to the construction division which is considered as the profit-making division. In companies where the construction division is dominant, the contractor's project engineer lacks the authority to withhold release of drawings until they are properly checked, or the authority to procure enough manpower to release well-checked drawings to the field on schedule. Hence, in working with such companies, you as the only responsible representative of the operating company on the site, are the only one who can force the construction people to build the plant to your design specifications. And you can only do so if your management gives you enough help, particularly near the end of the job, to undertake thorough inspection of everything. The inspection cannot be merely a welding inspection, it must also cover *all* aspects of the design, mechanical and process. Here the staff responsible for future operation of the plant can help you greatly, by covering the process aspects, if assigned early to the task by your management.

Agreement on Engineering Procedure. Early in the design, an "operating manual" on the respective functions and responsibilities of yourself and the contractor should be prepared, and the limits of the contractor's authority defined. The coverage for engineering might be as given below:

Scope of Contractor's Responsibility. Two types of responsibility are considered: (1) functional, and (2)

responsibility for itemized specific process facilities, etc.

For the project as a whole, the contractor's functional responsibilities might, for example, be described as engineering, procurement, and construction. However, inasmuch as this discussion deals primarily with engineering and the relationships of other groups to engineering, there should be a further breakdown of the engineering functional responsibilities. This is intended to show whether the operating company or the contractor will assume the responsibility for each of the following items:

- Securing process license agreements.
- Providing physical and chemical data for feed and product streams.
- Process design, including line and equipment sizing, and the tray layouts.
- Providing base lines, site survey and contour map.
- Soil investigations for foundations design.
- Engineering design, drafting, and checking (and the extent thereof).
- Equipment specifications, requisitions, quotations, and bid analyses.
- Subcontract requisitions, bids and analyses.
- Piping spoolsheets preparation.
- Material take-offs, requisitions, bids and bid analyses.
- Release of requisitions for purchase.
- Scheduling of all procurement, engineering and drafting.
- Information for estimating of original cost, and of changes and extras.
- Progress reports preparation.
- Checking of suppliers' drawings of all equipment.
- Record books preparation, including suppliers' drawings, instructions for installation, operation and services, and parts lists.

In the event the responsibilities for any part of the work are to be partly yours and partly the contractor's, there must of course be a detailed definition of the responsibility of each party to avoid trouble.

The Job Scope also includes a list of specific process and other facilities which are to be included in the contractor's work.

Items to be Furnished by Operating Company. Certain pieces of equipment are sometimes furnished by you without cost to the job. These can be listed in an attachment and assembly drawing numbers indicated for each, with a list of pertinent detailed drawing numbers on each assembly drawing.

Limits of Contractor's Authority. This section defines the extent to which the contractor may advance the job step-wise without your approval. For example, is the operating company's approval required in the case of all process and engineering flow diagrams, plot plans, principal structures and buildings? Generally, this is the case. Approval of bid summaries may be required in the case of all purchases greater than a certain dollar value. Approval of process design may be necessary before any engineering design work can proceed. Design changes and extras ordinarily require your approval before any engineering work is done. Instructions to the contractor, without written confirmation, have no standing, and follow-up on all instructions is imperative. No overtime work is authorized without written approval.

Contract Summary. Two points should be covered here. First of all, for the benefit of those who don't see the contract, it should be stated under what type of contract the job is being done; for example, lump sum, cost-plus-fixed-free with division of savings, cost-plus-percentage fee with the goal of arriving at a negotiated lump sum price at a later date, etc. Secondly, attention should be drawn to any unusual provisions of the contract.

Responsible Personnel List. The names and addresses of both your and the contractor's personnel in the following categories are listed for future reference and for mail distribution:

- Project Managers and Project Engineers
- Construction Superintendent
- Chief Process Engineers
- Others to whom mail may be addressed

Progress Reports. Indicate both the type and frequency of progress reports required by you. These will include a weekly construction progress letter, the monthly engineering, procurement, and construction progress report, and the monthly purchasing status report, together with others specifically requested by you, such as expediting and inspection reports.

Schedule. Indicate when you plan to release all information to allow engineering to begin, the contractor's estimated dates for all drawings to be in the field, also the contemplated start and completion of construction. Indicate such items as the target date for release of the Definitive Estimate and Design Specifications Books to your company.

Process Design (if required). Include a brief discussion of the following items:

- What process licenses are required and from whom secured?
- Provision for securing operating data from existing units involved in this project.
- Source of physical and chemical data.
- Description of processing methods.
- Material and heat balances.
- Equipment process specifications.
- Process flow diagram.
- Performance guarantees required (Process, Chemicals, and Utilities).

Engineering Responsibilities. Discuss the following points concerning the engineering design. Lengthy tabulations, etc., of design information should merely be referred to and not included in the body of the Project Scope and Procedure.

- Basic design data, such as weather, winds, temperature, frost line, the utilities available, etc.
- Project specifications (detailed).
- List of your engineering standards and general specifications.
- List of engineering and governmental codes or regulations which must be observed, for example, state safety codes.
- List of approved suppliers.
- List of items requiring shop inspection.
- Inspection tolerances.
- Site surveys, soil test reports,

Get with your contractor early and "smoke out" those suppliers whose workmanship is known to be bad

location plan and plot limits, accessibility of area, and hazardous area locations.
- Area for construction facilities and parking.
- Underground obstructions.
- List of reference drawings for tie-in locations, outline dimensions of existing equipment, etc.
- Distribution list for all correspondence, conference notes, reports, and drawings.
- Correspondence procedure (for example: use only one subject per letter, the method of heading correspondence, use of your job number on letters, etc.).
- Equipment, instrument, and line numbering methods of your company.
- Numbering methods for requisitions, suppliers' drawings, etc.
- Drafting procedure, including matters of drawing sheet sizes, form of title block, paper or cloth, drawing numbers, revisions numbers, the use of your drawing papers, etc.
- Building permits—backup information for procuring, and state who procures these.
- Procedure for change orders and extra work.
- Record books—inclusions; number of copies; and when required by you (prior to plant start-up).
- Recommended spare parts—when required by you.
- Final transparencies of all drawings. Are these to be of the "as built" plant or only equipment?

Engineering Design—Miscellaneous Points. Certain points appear worth mentioning inasmuch as they apply rather generally. For the same contractor, engineering expenses can vary from as low as 5 percent to as high as 20 percent of job cost, depending primarily upon the firmness of the operating company's process design, the adequacy of its general engineering specifications and standards, and the effectiveness of its project engineer.

An expensive place to attempt to save money is by overly shrinking the plot plan. This either congests the entire plant, causing increased drafting, construction and engineering costs, and increasing fire hazard, or it pushes the plant up in the air and increases structural steel and maintenance costs. One check list by the writer to guide plot plan spacing appeared in the October, 1958 Refiner,[6] and the subject has been well covered in Armistead's "Safety in Petroleum Refining."

If at all possible, design the plant for location outside rather than inside a building, thereby saving on both building and drafting costs, and reducing fire hazards. If some shelter is required to facilitate pump maintenance in wet climates, try to get by with a roof only. In severe climates, of course, it is recognized that pumps and many other items must be located inside.

The contractor's layout man should have considerable previous experience. If the plant is not laid out properly to begin with, all subsequent work by the drafting department and the construction crew merely compounds the original errors in layout.

It is always wise, however, to secure the comments of your operating and maintenance people on the layout.

Early in the design, it should be settled where all elevated piping blinds, control and relief valves, orifices, external manways and manual valves are to be located inasmuch as an access platform will be required for each, and this requires planning.

Settle also just how you can tie-in the new process with adjacent existing processes. Perhaps extra valves, piping or even extra equipment will be required to avoid a lengthy and costly shut-down of existing equipment for tying-in.

It is well to constantly bear in mind whether adequate provisions are being made for plant maintenance. For example, provide A-frame truck (or mobile hoist) access to all equipment and piping for repairs, access to furnace tubes, exchanger bundles, vessels, trays, etc. The contractor's engineers are not ordinarily as maintenance-minded as engineers of the operating company, and they must therefore lean on you for guidance. Complete maintenance facilities *only* after securing the comments of your company's maintenance people, particularly those who will be assigned to this plant.

Spare Parts are of particular importance during the plant start-up, hence they must be ordered early. Your management loathes the idea of having a large and costly plant inoperative for want of a few spare parts. The contractor's purchasing department must be urged to expedite manufacturers' parts lists as soon as orders are placed for equipment; and upon receipt, they should be gone over carefully with the maintenance people responsible for the new plant, and orders placed.

Enough steam-driven spare process pumps, compressors, and cooling water pumps are generally provided to at least allow for an orderly shutdown of plant in the event of power failure. Automatic emergency power for instruments and critical lights is essential.

For some costly equipment, like centrifugal compressors, piped-up spares are not always provided. Instead, a warehouse spare case and impeller may be considered for each instance where necessary.

Scheduling of the Work. As can well be imagined, this is one of the most important phases of the work. In fact, in many contractor's organizations, the Scheduling Department "calls the signals." It is given the responsibility of establishing a reasonable sequence of design, ordering, release of drawings, equipment and materials delivery and installation to the end that the target completion date is met. By "reasonable" is meant that whatever manpower is necessary to accomplish this can actually be supplied by the contractor.

"First things first" is the byword, and hence one can realize that the engineering sequence must be fixed by the contractor. Any interference with this schedule by the operating company will often be the occasion of much furor, particularly on the fixed-price job. It is too late for further improvement of the process design. You must get all interested parties in your company to approve equipment specifications promptly for bid and to approve drawings quickly for construction. From this time

until the piping drafting is completed, your most effective spot will be in the contractor's engineering offices, provided you have inspectors in the field.

Following settlement of the license agreement and process design, the furnishing of your complete engineering standards, specifications and approved list of suppliers to the contractor, along with your reference drawings of existing plants, a job procedure is drawn up and a manpower forecast made, along with the equipment procurement schedule, drafting schedule, and detailed piping specifications.

Subsequently work goes forward with the engineering flowsheets, the physical layout, equipment specifications for bid, and architectural studies. Then comes the piping and structural drawings, vessel and tank drawings, preliminary piping takeoff, instrument specifications for bid, and electrical equipment and materials.

By this time enough information should be available to allow foundations, excavations and fill, and underground drawings to start, bid analyses on equipment to be made, orders placed, and equipment suppliers' drawings to be expedited (without which the layout and piping drafting cannot go forward).

Eventually, all excavation and fill drawings, underground drawings, and major foundations are released to the field, allowing them to start (if the weather is favorable). The piping, structural, electrical and instrument drafting squads have, by then, been given a firm layout. Piping spoolsheets begin and the critical alloy spools are released for fabrication.

By this time, suppliers' drawings have been pouring into the engineering office for approval. Approval is given promptly after checking because if approval is delayed, this will often be the occasion for an extra by a supplier, if he is to meet his schedule. Final material takeoffs are in progress, spoolsheets are being finished, and pump foundations done. Insulation specifications are placed out for bid, and award of the subcontract is made.

Finally, after most of the job engineers' work is done, record books are assembled containing design, installation, operation and maintenance information on all process equipment. These must be expedited to the operating personnel for preparation of an operating manual prior to the start-up date.

Procurement. At the beginning of a job, your lists of approved equipment and material suppliers and approved subcontractors are discussed fully with the contractor's Purchasing Department with a view toward "smoking out" suppliers whose workmanship is as yet unproved or who have consistently caused trouble in the past on service, quality of materials, by consistently high bids, too many extra charges, or in late delivery of either the certified prints or the equipment itself. If the local representatives are only "5 percenters" and have no exclusive representation, the contractor should try to deal directly with the equipment manufacturers.

Reciprocity deals recommended by your own Purchasing Department should not be allowed to place someone on the bidders' list who has caused trouble in the past, otherwise the contractor's target completion date will be placed in jeopardy.

Bids are costly to prepare. Therefore, it is unfair to include on the bidders' list a supplier who stands no chance to get the business if he is low.

Attention should be paid to getting the best discounts on purchases. For example, it is often best to order drivers separate from pumps (for domestic plants).

There are many excellent buyers in contractors' purchasing departments; but their abilities will in no way redound to your benefit or the benefit of anyone else if they are overloaded with work. The same is true of the contractor's expediters and inspectors.

With reference to inspection, in establishing the list of equipment, spools and castings which are to be inspected at the shop, consider the cost of the inspection versus the freight costs and job delays if the equipment must be returned to the shop for repairs because it was not shop-inspected. Also enforce the usual contractual agreement that *all* equipment is to be inspected at shop or field by the contractor. In some instances, the field inspection is skimpy due to lack of personnel. Costly machinery and equipment should preferably be inspected by the engineer who wrote the specifications.

It is suggested that suppliers' drawings, parts lists, operating and service instructions, in the required number, be made a part of the material requisition and that each bidder guarantee the dates on which these will be mailed. Sometimes these can bottleneck the job. Sometimes suppliers seek extra money for a large number of copies.

While the project engineer for the operating company may, under certain circumstances, deem it wise to deviate from certain of the foregoing points, it is hoped that in general they will prove a useful guide to those new in the project management field. In particular, the objective here has been to minimize oversights and not to establish any set of rules which must be followed blindly. There are no substitutes for experience and ingenuity in the management of the engineering project.

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About the Author

John F. McGarry has wide experience in process design and operating supervision of chemical and petroleum processes. During part of his 16 years' experience with Shell Oil and Shell Chemical companies, he was in charge of process design for Shell Chemical, and was assistant superintendent, Houston chemical plant. In these jobs he worked closely with several different engineering and construction contractors in initial engineering phases and plant startups. He was with Bechtel Corp. for six years as a project engineer, and in 1956 became an engineering consultant. Mr. McGarry also lectures in plant design at the University of California, College of Engineering.

Use this guide to compare . . .

European vs. U.S. Steel Specifications

Study of European steels suitable for petroleum refining construction reveals European standards of comparable quality to ASTM specifications

M. S. Northup and A. R. Ciuffreda
Esso Research & Engineering Co.
Linden, N. J.

MOST EUROPEAN carbon steel grades are covered by national standards. For certain grades, the European carbon steels may be subjected to more testing than is required for ASTM steels. Many of the alloy steels are not adequately covered by the national European standards and reference to ASTM specifications is advisable.

Differences. Some of the principal differences between European and ASTM steel specifications may be summarized as follows:

1. ASTM specifications place limitations on chemical composition as well as mechanical properties for all steels excepting the lowest grades of structural steel. Many European specifications do not restrict the chemical composition with the exception of undesirable contaminants such as phosphorous and sulfur.

2. European specifications for some steels permit mill certification or guarantee of properties based on routine quality control. However, mill inspection by the customer and testing according to the specification may be requested.

3. The mechanical characteristics guaranteed in most European specifications are more inclusive than corresponding ASTM specifications. For example, in Germany pressure vessel steels have a guaranteed impact value at 20° C (68° F) and are certified as to certain high temperature characteristics as well.

4. European specifications require that test specimens be taken transversely to the direction of rolling rather than logitudinally as specified in ASTM. The European method gives a better indication of the minimum tensile properties.

5. The "homogeneity test" required in ASTM A-20 for qualifying pressure vessel steels is not required in any of the European countries. The transverse tensile specimen is used to obtain equivalent information on the presence of laminations and slag inclusions.

6. The thickness and weight tolerances in ASTM A-6 and A-20 differ from those in Europe. European mills apparently demand more liberal tolerances and experience difficulty in working to these ASTM requirements.

7. Continental European boiler and pressure vessel steels are killed and normalized. Also, structural steels made to "fine grain" practice (similar to ASTM A-131 Grade C) are given a normalizing heat treatment to insure the desired result. Corresponding ASTM steels are not normally given this beneficial treatment except for plate thicknesses over 2 inches.

EQUIVALENT U.S. AND EUROPEAN STEELS

Belgium. The procurement of steels from the mills to ASTM or other foreign specifications is no problem in Belgium. It is possible to obtain all ferritic steels up to and including the nine percent Cr one percent Mo steel. High alloy steels are not produced. The steels covered by standards of the Institute Belge de Normalisation (NBN) are used primarily for national industries such as railroad, etc. However, at times these NBN steels may be more readily available in small quantities than the desired ASTM steel.

The bulk of the plate produced in Belgium is either rimmed or fully-killed steel. Semi-killed steel is produced, but in relatively small amounts. In most instances, ASTM pressure vessel steels purchased in Belgium may be killed and normalized even when the specification does not require such processing. Some mills prefer to roll a test ingot to determine whether normalizing is required to meet the particular ASTM requirements.

Most of the Belgium structural shapes and plates are produced from Thomas converter steels. These may be of all qualities from the ordinary grades to the more recently developed improved grades. Unless open hearth steels are specified, the Belgium structural shapes will be supplied from converter steels.

France. The French steelmakers are entirely agreeable to the use of ASTM specifications. Many steel specifications of the French Standards Association (AFNOR) have not been revised in more than ten years. The AFNOR specifications are used by some French industries, but the steel mills do not adhere strictly to the specification as written. Carbon steels may be purchased to ASTM specifications without modification on the same basis as the AFNOR steels. There are no AFNOR specifications for alloy steels. These steels are produced to mill specifications and are sold under trade names. The mill requirements on alloy steels follow

TABLE 1—American and European Steel Specifications for Equivalent Quality

U.S. ASTM Specification		BELGIUM NBN		GREAT BRITAIN BS		FRANCE NF	FRANCE AFNOR	GERMANY DIN	GERMANY DIN	ITALY UNI	ITALY UNI
		No.	Type	No.	Type	No.	Type	No.	Type	No.	Type
A-7	Steel for Bridges and Buildings	152.21 152.21	A42KHS[1] A42HS[1]	15	No. 1[2]	A35-101 A36-203	A42T2S[1] A42T2S[1]	100 17100	MST42-2[1]	743	AQ42 .....
A-53	Welded and Seamless Steel Pipe										
	Grade A	.....	.....	1507-51	[3]	A48-001	A37-3S	1629[4] 17175	SMST35.2S SMST35.8	663C13	AQ35
	Grade B	.....	.....	.	.....	.....	.....	1629[4] 17175	SMST45.2S SMST45.8	a	.....
A-83	Seamless Steel Boiler Tubes										
	Grade A	.....	.....	1508-151	.....	.....	.....	17175	SMST35.8S	.....	.....
A-105	Forged or Rolled Pipe Flanges for High Temperature Service										
	Grade I	.....	.....	1503-151[6]	Gr.B	A33-101	A42-3S	17200	C22[8]	1757	AB1
	Grade II	.....	.....	1503-151[6]	Gr.C	A33-101	A48-3S	WBL620	15Mo3 C35[8]	1757	AB2
A-106	Seamless C-Steel Pipe for High Temperature Service										
	Grade A	.....	.....	1604	Gr.A	A35-001	A33-3S	17175	SMST35.8S	663C13	AQ35
	Grade B	.....	.....			A35-001	A42-3S	17175	SMST45.8S	.....	.....
A-131	Structural Steel for Ships										
	Grade B	a	.....	2762[a]	NDI	a	.....	a	.....	a	.....
	Grade C	a	.....	2762[a]	NDII	A36-203	A42T-3S[3]	17155	H-II	815 Caldaia	AQ42
A-161	Seamless Low C and C-Mo Steel Still Tubes for Ref. Service	.....	.....	1730	.....	.....	C10d or C20d[7]	17175	SMST35.8S	663C or D	AQ35
A-167	Corr. Resisting Cr-Ni Steel Plate and Sheet										
	Grade 2	.....	.....	1501-801	Gr.A	6	Z10CN18-08	WBL401[6]	X12CrNi18-8	S115[6]	X12CN188
	Grade 3	.....	.....	1501-801	Gr.B	6	Z8CN18-08	WBL401[6]	X5CrNi 18-9	S115[6]	X12CN188[8]
	Grade 11	.....	.....	1501-845	Gr.B	6	Z8CNDT18-08	WBL401[6]	X5CrNiMo 18-10	S115[6]	X10CND188[8]
A-179	Seamless Cold Drawn Low C Steel	.....	.....	1627	.....	7	C12d	1629[4] 17175	SMST35.2S SMST35.8	2897	AQ35
A-181	Forged or Rolled Steel Pipe Flanges, Fittings and Valves for General Service										
	Grade I	.....	.....	1503-151	Gr.B	A33-101	A42-3S	17200	C22	1757	AB1[9]
	Grade II	.....	.....	1503-151	Gr.C	A33-101	A48-8S	WBL620 17200	15Mo3 C35	1757	AB2[9]
A-182	Forged or Rolled Alloy Steel Pipe Flanges, Fittings, and Valves for High Temperature Service										
	Grade F5	.....	.....	1503-625	10	6	Z20CD5	WBL590[6]	12CrMo 19-5	a	.....
	Grade F11	.....	.....	1503-621	11	.....	.....	a	.....	a	.....
	Grade F22	.....	.....	.....	.....	6	Z10CD9	a	.....	a	.....
	Grade F304	.....	.....	1503-801	Gr.B	6	Z3CN18-08	WBL400[6]	X5CrNi 18-9	S115[6]	X12CN188[8]
	Grade F316	.....	.....	1503-845	Gr.B	6	Z3CND17-11	WBL400[6]	X5CrNiMo 18-10	S115[6]	X10CND188[8]
	Grade F321	.....	.....	1503-821	Gr.B Ti	6	Z6CNT18-09	WBL400[6]	X10CrNiTi 18-9	S115[6]	X8CNT188
	Grade F347	.....	.....	1503-821	Gr.B Cb	.....	.....	WBL400[6]	X10CrNiNb 18-9	.....	.....
A-193	Alloy Steel Bolting Materials for High Temperature Service										
	Grade B7	.....	.....	1506-621	Gr.A	6	42CD4b	17200	42Cr-Mo4	2954	38NCD4
	Grade B14	.....	.....	1506-661	a	a	.....	17240	24Cr-Mo V55	a	.....
	Grade B8C	.....	.....	1506-821	Gr.B Cb	a	.....	.....	.....	.....	.....
	Grade B8T	.....	.....	1506-821	Gr.B Ti	6	Z6CNT18-09	7	X10CrNiTi 18-9	S115[7]	X8CNT188
A-194	C- and Alloy Steel Nuts for Bolts for High Temperature Service										
	Grade 2H	.....	.....	a	.....	7	C45d	7	C45	1743[7]	AQ60
	Grade 4	.....	.....	a	.....	.....	.....	7	24CrMo5	a	.....
	Grade 8	.....	.....	a	.....	7	Z3CN18-08	7	X5CrNi 18-9	S115	X8CNT188
A-199	Seamless Cold Drawn Intermediate Alloy Steel Heat Exchanger and Condenser Tubes										
	Grade T5	.....	.....	1628	Gr.B	7	Z10CD5	a	.....	a	.....
	Grade T22	.....	.....	1628	Gr.A	7	Z10CD9	a	.....	a	.....
A-200	Seamless Intermediate Alloy Steel Still Tubes for Refinery Service										
	Grade T5	.....	.....	1731	Gr.B	7	Z10CD5	a	.....	a	.....
	Grade T22	.....	.....	1731	Gr.A	7	10CD9	a	.....	a	.....
A-201	C-Si Steel Plates of Intermediate Tensile Range for Boilers and Other Pressure Vessels										
	Grade A	205.21	D37MHS	1501-154	Gr.B	A36-205	A37C3Sr	17155	H-II	815 Caldaia	AQ42[12]
	Grade B	205.21	D42MHS	1501-154	Gr.C	A36-205	A42C3Sr	17155	H-III	815 Caldaia	AQ42[12]
A-204	Carbon Molybdenum Steel Plates										
	Grades A & B	.....	.....	1501-240	Gr.B	a	.....	a	.....	a	.....
A-212	High Tensile Strength C-Si Plates for Boilers and Other Pressure Vessels										
	Grade A	a	.....	1501-154	Gr.C[13]	A36-205	A48C3Sr	17155	H-III	815 Caldaia	AQ48[12]
	Grade B	a	.....	.....	.....	a	.....	a	.....	815 Caldaia	AQ53[12]
A-213	Seamless Alloy Steel Boiler, and Heat Exchanger Tubes										
	TP 304	.....	.....	1508-801	8	7	Z3CN18-08	7	X5CrNi 18.9	S115	X8CN188
	TP 310	.....	.....	1508-825	.....	7	Z20CNS25-20	a	.....	S115	X15CN2420
	TP 347	.....	.....	1508-821 Cb	.....	.....	.....	a	.....	.....	.....
A-214	Electric Resistance Welded Heat Exchanger and Condenser Tubes	.....	.....	a	.....	a	.....	a	.....	a	.....
A-216	C-Steel Castings Suitable for High Temperature Service										
	WCB	.....	.....	1504-51	6	a	.....	172456 172456	GS-C25[14] GS-22Mo4[15]	a	.....

U.S. ASTM Specification	BELGIUM		GREAT BRITAIN		FRANCE		GERMANY		ITALY	
	NBN		BS		NF	AFNOR	DIN	DIN	UNI	UNI
	No.	Type	No.	Type	No.	Type	No.	Type	No.	Type
A-217 Alloy Steel Castings for Pressure Containing Parts Suitable for High Temperature Service										
WCI	.....	.....	1504-240	Gr.A[6]	[a]	.....	17245[6]	GS-22Mo4	[a]	.....
WC6	.....	.....	1504-621	[16]	[7]	35CD4	17245[6]	GS-22CrMo 54	[a]	.....
WC5	.....	.....	1504-625	[15]	[a]	.....	[7]	GS-12CrMo 19-5	[a]	.....
WC12	.....	.....	1504-620	[14]	[a]	.....	[7]	GS-12CrMo 9	[a]	.....
A-240 Corr. Resisting Cr and Cr-Ni Steel Plate for Fusion Welded Unfired Pressure Vessels										
S	.....	.....	1501-801	Gr.B	[7]	Z3CN18-09	WBL401	X5CrNi 18-9	S115	X8CN188
A	.....	.....	1501-613	.....	[7]	Z10C13	WBL401	X10C13	S115	X10C13
C	.....	.....	1504-821	Gr.B Cb	.....	.....	WBL401	X10CrNiNb 18-9	.....	.....
T	.....	.....	1504-821	Gr.B Ti	[7]	Z6CNT18-09	WBL401	X10CrNiTi 18-9	S115	X8CNT188
A-245 Heavy Gage Structural Quality Flat Hot-Rolled C-Steel Sheets										
Grade C	153.21	A37HS	1501-101	.....	A36-203	A37T2S	1621 1622	St37.21S St37.22S	S15	AQ42
A-263 Corr. Resisting Cr Steel Clad Plate, Sheet and Strip										
Grade O	.....	.....	[a]	.....	[a]	.....	[a]	X5CrAl-13	.....	.....
Grade A	.....	.....	1501-613	[a]	[a]	.....	[a]	X10Cr-10	.....	.....
A-264 Corr. Resisting Cr-Ni Steel Clad Plate, Sheet and Strip										
Grade 3	.....	.....	1501-801	Gr.B[7]	[7]	Z3CN18-09	WBL400	[7] X5CrNi 18-9	.....	.....
Grade 5	.....	.....	1506-821	Gr.B Ti[7]	[7]	Z6CND18-09	WBL400[7]	X10CrNiTi 18-9	.....	.....
Grade 6	.....	.....	1501-821	Gr.B Cb[7]	.....	.....	WBL400[7]	X10CrNiNb 18-9	.....	.....
Grade 11	.....	.....	1501-845	Gr.B[7]	[7]	Z6CND17-11	WBL400[7]	X5CrNiMo 18-10	.....	.....
A-265 Ni and Ni Base Alloy Clad Steel Plate (70/30 Ni Cu)	.....	.....	[a]	.....	.....	.....	[6] [17]	Ni67Cu	.....	.....
A-271 Seamless Austenitic Cr-Ni Steel Still Tubes for Refinery Service										
TP-304	.....	.....	1508-801	[a]	[7]	Z3CN18-09	[7]	X5CrNi 18-9	S115[7]	X8CN188
A-283 Low and Intermediate Tensile Strength C-Steel Plates of Structural Quality										
Grade C	153.21	A37HS	1501-101	.....	A36-203	A37T2S[3]	17100	MST37-2	S15	AQ42
A-285 Low and Intermediate Tensile Strength C-Steel of Flange and Firebox Quality										
Grade C	205.12	D42M	1501-151	Gr.B	A36-205 A36-205	A37C38r[3] A42C38r[3]	17155	H-II	S15 Caldaia	AQ42
A-300 Steel Plates for Pressure Vessels for Service at Low Temperature	[a]	.....	[a]	.....	[a]	.....	[a]	.....	[a]	.....
A-307 Steel Machine Bolts and Nuts and Tapbolts										
Grade B	.....	.....	[a]	.....	[a]	.....	267	5D (ST50.11)	[a]	.....
A-312 Seamless and Welded Austenitic Stainless Steel Pipe										
TP-304	.....	.....	1607	Gr.P 8A	[7]	Z3CN18-09	[7]	X5CrNi 18-9	S115[7]	X8CN188
TP-321	.....	.....	1607	Gr.P 8B	[7]	Z6CNT18-09	[7]	X10CrNiTi 18-9	S115[7]	X8CNT188
TP-347	.....	.....	1607	Gr.P 8D	.....	.....	[7]	X10CrNiNb 189	.....	.....
TP-316	.....	.....	1607	Gr.P 8E	[7]	Z6CND17-11	[7]	X5CrNiMo 18-10	[7]	X8CND188
A-320 Alloy Steel Bolting Material for Low Temperature Service										
L7	.....	.....	1506-621	Gr.A [7]	[7]	42CD4h	[7]	42CrMo 4	[a]	.....
B8	.....	.....	1506-801	Gr.B[7]	[7]	Z3CN18-09	[7]	X5CrNi 18-9	[a]	.....
A-335 Stainless Ferritic Alloy Steel Pipe for High Temperature Service										
P5	.....	.....	1607	Gr.P 5A	[7]	27CD5	[a]	.....	[a]	.....
P11	.....	.....	1607	Gr.P 3A[18]	[7]	10CD5	[a]	.....	[a]	.....
P22	.....	.....	[19]	.....	[7]	10CD9	[a]	.....	[a]	.....
A-351 Ferritic and Austenitic Steel Castings for High Temperature Service										
CA-15	.....	.....	1504-613	[7]	.....	.....	WBL4107	GX25Cr 14	[a]	.....
CF-8	.....	.....	1504-821	[7]	.....	.....	WBL4107	GX5CrNi 18-9	[a]	.....
CF-8M	.....	.....	1504-845	[7 8]	.....	.....	WBL4107	GX5CrNiMo 18-10	[a]	.....
A-357 5% Cr ½% Mo Steel Plates for Boilers and Other Pressure Vessels	.....	.....	[a]	.....	[a]	Z20CD5	WBL5006	12CrMo 19-5	[a]	.....
A-387 Cr-Mo Steel Plates for Boilers and Other Pressure Vessels										
Grade B	.....	.....	[a]	.....	[a]	.....	[a]	.....	[a]	.....
Grade D	.....	.....	[a]	.....	[a]	.....	[a]	.....	[a]	.....

SYMBOLS: SM } Siemens Martin Process S—Weldable Quality WBL—Stahl-Eisen Werkstoffblatt (Vereins Duetscher Eisenhuttenleute)
M }

[a] Normally produced to ASTM Specifications. In case of alloy steels leading mills may market equivalents under a company designation.

NOTES: [1] Mill certification must be requested. Siemens-Martin steel of welding quality is to be preferred for welded construction. Semi-killed or aluminum-killed improved Thomas steels complying with the following added composition requirements are acceptable substitutes:

	Semi-Killed	Aluminum-Killed
Nitrogen	0.007%	0.009%
Phosphorous	0.04 %	0.05 %
Sulfur	0.03 %	0.04 %

Other grades of weldable improved Thomas steel may be used for bolted or riveted construction and for non-critical structural parts such as stairways, platforms, tower internals, roofs of floating roof tanks, etc.

[2] Specify open hearth process.
[3] Specify welding grade.
[4] Limited to 350°C (662°F) in Germany (DIN 2385).
[5] This is considered a non-welding grade.
[6] Inspect to ASTM specification except for chemical and mechanical testing.
[7] Inspect to ASTM specification except for chemical composition.
[8] Specify 0.08% max. carbon content.
[9] Specify 0.35% max. carbon content.
[10] Specify 0.15% max. carbon content and 60,000 psi min. tensile strength.
[11] Specify 0.20% max. carbon content and 70,000 psi min. tensile strength.
[12] Specify silicon killed.
[13] Tensile strength is 62,500 psi min. instead of 65,000 psi min.
[14] Limited to 475°C (885°F) in Germany.
[15] Limited to 525°C (977°F) in Germany.
[16] Specify 0.20% max. carbon content.
[17] Specify 2.5% max. iron content.
[18] Contains 1-¾% chromium instead of 1-¼% chromium.
[19] No comparable British Standard. Substitution of B.S. 1607-P3C may by made if designed accordingly.

closely those of the corresponding ASTM specification.

Alloy clad plate is available with 11-13 percent chromium and stabilized 18 percent chromium 8 percent nickel stainless cladding. No monel clad plate is produced in France. In making the 11-13 percent chromium cladding, the French use an electrolytically deposited nickel bond layer betwen the alloy and carbon steels. Unlike the situation in Germany, the cost of 11-13 percent chromium steel cladding in France is 30 percent lower than that of 18 percent chromium 8 percent nickel stainless steel cladding for the same thickness of alloy.

Germany. There is a strong desire on the part of steel mills and fabricators in Germany to use the DIN national specifications of the Deutschen Normenausschuss (DNA). This is particularly true of equipment which is to be used in Germany as it simplified obtaining approval of the national code authority, Technischer Uberwachungs-Verein (TUV). In certain cases, TUV inspectors have delayed construction by requiring further testing of ASTM steels in accordance with DIN specifications. Additionally, steel plants usually require minimum orders of 30-100 tons to produce to an ASTM specification.

DIN steel specifications are available for carbon steels and low alloy compositions up to one percent chromium. These specifications cover both mechanical characteristics and chemical composition in sufficient detail to guarantee the quality of steel supplied. The low chromium alloy steels (1 to 5 percent chromium-molybdenum steels) have been produced largely for the export market to ASTM specifications and there are no German specification equivalents. In view of the familiarity of German mills with ASTM specifications for these alloys, there is no special problem in ordering them to the American standards.

The higher alloy steels are not covered by DIN specifications, but do appear in industry standards issued by the German Iron and Steel Institute (VDEh). These specifications (Werkstoffblatt) are in many respects more comprehensive than the corresponding ASTM specifications. For example, in the case of stainless steels, provision is made in the German specification for a variety of corrosion tests which are not normally required in corresponding ASTM specifications. For the most part, these alloy steels can also be purchased to German chemical composition and mechanical properties with inspection according to ASTM specification.

In the case of 11-13 percent Cr steel cladding, an intermediate layer of monel (0.2mm) may be used to facilitate bonding. As a result of this practice, the cost of 11-13 percent chromium clad steel in Germany is about the same as for 18 percent chromium 8 percent nickel stainless clad plate. In addition, the 18 percent chromium 8 percent nickel stainless cladding is more readily available and fabricators have had more experience with this material.

Great Britain. The situation in Great Britain is similar to that in Germany in that the national standards are widely used and are preferred by the steel mills. However, the British Standards Institute specifications covering steels for the petroleum and allied industries (BS 1501-1508, 1607, 1631, 1731) are similar to corresponding ASTM specifications.

Use of the ASTM specifications in Britain usually entails a longer delivery and cost extras which are charged according to the British pricing system for added test requirements. Even when the steel is ordered to ASTM, the steel mills do not guarantee that the ASTM inspection or tolerance requirements will be followed strictly. This is to say that the main body of the ASTM specification such as ASTM A-7 and A-285 will be met, but that added requirements imposed by such general specifications as ASTM A-6 and A-20 are not adhered to.

Most of the grades of carbon and alloy steels can be supplied according to British standards. It is of interest that the AISI Type 304 stainless steel (BS 1503-801) is not considered suitable by the British for elevated temperatures and their specifications advise against its use above 950° F (510° C). The columbium or titanium stabilized grades of stainless steels are preferred instead. In the U. S. the Type 304 steel is used at considerably higher temperatures.

The British have moved ahead in preparing a national specification covering carbon steels especially designed for good notch toughness at low temperatures. These are covered in specification BS-2762.

Italy. All Italian steel plate and heavy structural members are rolled from open hearth or electric furnace steels. Carbon steels for domestic use in Italy are produced to UNI (Unificazione Italiana) specifications. However, the steels so standardized are primarily structural steels. Steels for boilers and pressure vessels are ordered with the informal designation "caldaia" supplementing the standard structural plate designation. Steels of this type are accepted by the ANCC (Associazione Nazionale Controllo Combustione), the Italian code authority. These steels have been used in refinery pressure vessels without difficulty.

There are no UNI specifications for alloy steels although designations indicating composition ranges (similar to AISI numbers) have been standardized. The larger mills have adopted ASTM alloy specifications and are marketing these steels under trade names.

The Italian steel mills are willing to produce to ASTM specifications and usually there is no additional cost over the UNI steel of comparable quality. However, fabricators are currently using UNI structural steels almost exclusively. If small quantities of ASTM pressure vessel steel are required, the fabricator may purchase to a UNI specification and then qualify the material to the ASTM specification by making any additional tests required. Although in general no particular problem exists in obtaining ASTM carbon steels on advance mill purchases, there have been instances when small quantities of UNI steels were more readily available.

This article is a condensation of a paper entitled "Reconciliation of American and European Steel Specifications" presented by the authors to the Fifth World Petroleum Congress, New York, June 2, 1959. ##

Applied Hydrocarbon Thermodynamics

Part 14: Integral Technique for Vapor-Liquid Equilibria in Petroleum Distillation Calculations

Wayne C. Edmister
Oklahoma State University, Stillwater

EQUILIBRIUM VAPORIZATION calculations for petroleum fractions are usually made by empirical methods, such as those given in Parts 12 and 13, for which compositions are defined by analytical batch distillation curves. Similar calculations for multicomponent hydrocarbon mixtures are made by theoretical methods for which compositions are defined by the number of moles or the mole fraction concentrations of a discrete set of components.

Mixture Types. Both of these mixtures are "multicomponent" systems. The number of components in petroleum fractions are essentially infinite, however, the amount of each component being infinitesimally small. In other words, petroleum fractions are "continua" mixtures of an "infinite" number of components while light hydrocarbon gases and liquids are multicomponent mixtures of a "finite" number of components.

The components of light hydrocarbon mixtures can be identified by their individual formulae, names, and properties. Continua components, on the other hand, are identified by their boiling points and gravities, which are taken from the true boiling point (TBP) assay and supplemental data. These are generally presented in graphical form as temperature and gravity vs. percent vaporized.

Another type of mixture for which equilibrium vaporization calculations must be made is a combination of these two, i.e., a finite number of low and intermediate boiling components of discrete concentrations plus a continua mixture of an infinite number of components of infinitesimal concentration; in other words, light hydrocarbons plus an oil fraction.

Calculation Methods. The so-called theoretical method for making equilibrium vaporization calculations, using vapor-liquid distribution ratios (K values), can be applied to all these mixtures. The empirical method can be used only for the continua mixtures or petroleum fractions so application of this technique is limited.

A continua mixture may be represented as a multicomponent mixture of a finite number of hypothetical components so that equilibrium vaporization calculations can be made by the theoretical K value method. This breakdown of the continua mixture may be done by taking equal size cuts, say 20 at 5 percent width, each identified by its mean boiling point. For irregularly shaped TBP curves these "component" boiling points may be taken at irregular intervals.

Another way of breaking a petroleum fraction into hypothetical components for equilibrium vaporization calculations is to divide the fraction into narrow cuts of equal boiling point width but of varying quantities. Each of these narrow cuts are characterized by its average properties, i.e., boiling point and gravity.

These two methods of representing a continua mixture by hypothetical components simulate a smooth TBP curve by a series of plateaus. The larger number of components, the more accurate and tedious are the vaporization calculations made in terms of these components. The ultimate in precision would be an infinite component breakdown, if this can be done conveniently.

Such a method has been proposed[3, 4, 7, 8, 12, 17, 19] for making petroleum distillation calculations. Although the principle of the method is simple, previous applications were made by techniques which were either awkward or approximate. Because chemical engineers are more accustomed to numerical and graphical solutions of distillation problems, this type of application of the integral technique has been developed and is presented here.

The principles of this procedure are illustrated for four calculations on petroleum fractions by examples on: (1) equilibrium flash vaporization, (2) bubble and dew points, (3) fractional distillation, and (4) batch or differential vaporization.

Simplifications have been made in the integral method of making distillation calculations for petroleum fractions. In the present version of the method, conventional calculations are made for infinitesimal increments of the mixture, the results plotted, and the area under the curve found to check phase equilibria conditions and to obtain the total distribution for the mixture.

Previous Work. Katz and Brown[19] noted in 1933 that the same relationships used in making equilibrium vaporization calculations for simple mixtures (light hydrocarbons) could be applied in the differential form to complex mixtures (petroleum fractions) in which the composition is expressed as a true boiling point curve. Integrals rather than summations of the component contributions to equilibrium vapor and liquid were shown in the discussion of this method, but summations of segmental contributions were used in the illustrations.

A few years after this work, White and Brown[37] obtained experimental phase equilibria data on petroleum fractions (naphtha, furnace oil, and their mixtures) at high temperatures (300-820° F.) and pressures (50-700 psia). From the results of the equilibrium flash vaporization runs vapor-liquid equilibrium phase distribution ratios were derived for arbitrary hypothetical components, i.e., narrow cuts of 50° F. width. Quantities of these 50° F. cuts were read from the TBP curves. These liquid volume quantities were converted to moles, using gravities and molecular weights, and then K values were computed for each arbitrary component in the equilibrium vapor and liquid. These were plotted against temperature and pressure for average boiling points from 325-725° F. at 50° F. intervals.

A more fundamental method of analyzing these equilibrium vaporization data for petroleum fractions would

have been to work with infinitesimal increments of one degree or less. Applying the procedure used by White and Brown to such small arbitrary components would have magnified the data processing work considerably. Experimental vapor-liquid equilibria data for petroleum fractions can be put into K value form by using the integral technique presented in this and the next two installments.

In 1947 Harbert[17] proposed using differential curves instead of dividing the petroleum fractions into mixtures of artificial short boiling range components or making vaporization calculations by empirical methods based on laboratory vaporization data. In this previous work the TBP curve was used to define the complex mixtures of petroleum fractions.

Harbert put the TBP curve into differential form, so it could be used in making vapor-liquid equilibria calculations by plotting dM/dT_B vs. T_B (M represents moles and T_B represents boiling points). This differential is related to the reciprocal slope of the TBP curve by the

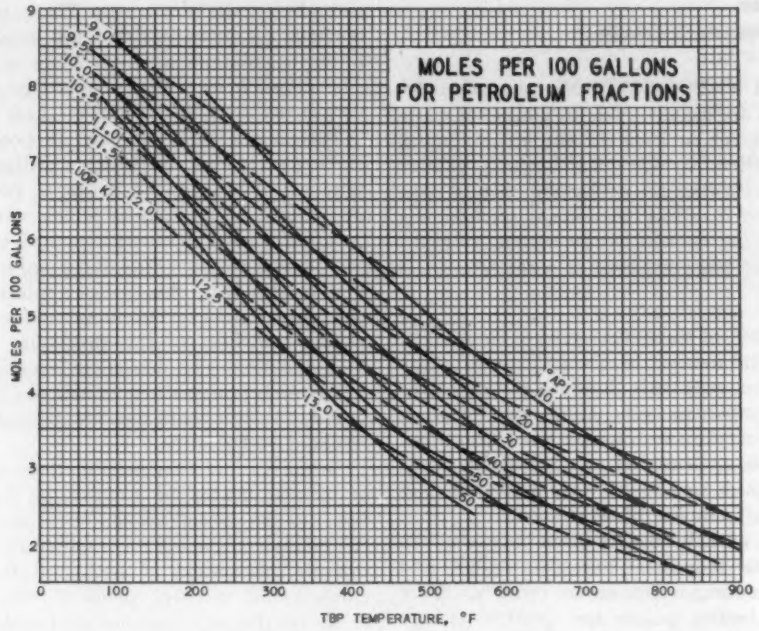

FIGURE 14.1—Moles per 100 gallons vs. TBP temperature and °API or UOP K for petroleum fractions.

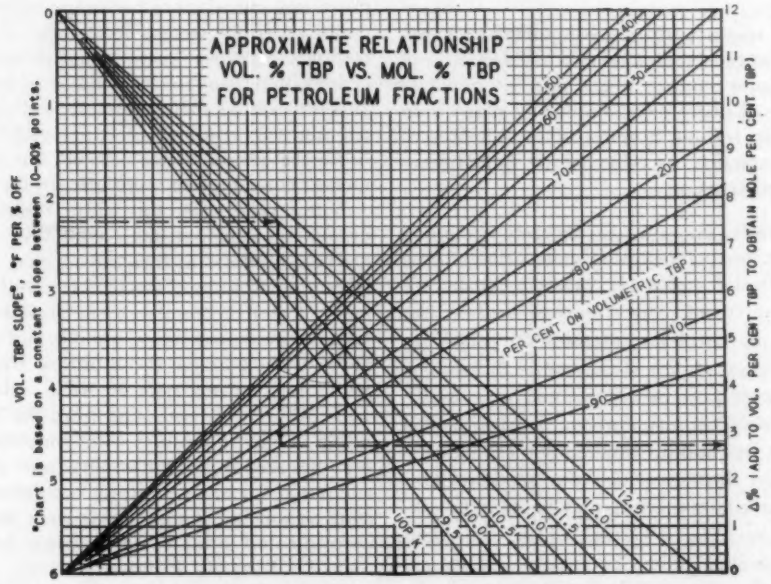
APPROXIMATE RELATIONSHIP
VOL. % TBP VS. MOL. % TBP
FOR PETROLEUM FRACTIONS
VOL. TBP SLOPE*, °F PER % OFF
*Chart is based on a constant slope between 10-90% points.
Δ% (ADD TO VOL. PER CENT TBP TO OBTAIN MOLE PER CENT TBP)
PER CENT ON VOLUMETRIC TBP
UOP K

FIGURE 14.2—Approximate relationship volume percent TBP vs. mole percent TBP for petroleum fraction.

following:

$$\left(\frac{dM}{dT_B}\right)=\left(\frac{dV}{dT_B}\right)\left(\frac{dM}{dV}\right)=\left(\frac{dV}{dT_B}\right)\frac{D}{MW} \quad (14.1)$$

where:

V = volume fraction distilled on TBP assay
D = liquid density of increment distilled
MW = molecular weight of increment distilled

Reciprocal slopes of TBP (i.e., dV/dT_B) were plotted against boiling temperature and then converted to dM/dT_B vs. T_B. This plot was used in the vaporization calculations with K values, which are added to the dM/dT_B vs. T_B plot as an extra scale that is alternate to the T_B scale.

The area under the dM/dT_B vs. T_B plot represents moles and the shape of this curve depends on the mixture and not the conditions of equilibrium vaporization. For different conditions, the auxiliary K scale will be changed. Bubble and dew point calculations and equilibrium flash vaporization calculations were made by using these differential curves.

The integral technique, presented here, is based on the same principles as that of Harbert.[17] The current procedure is more convenient in application, which will be described by demonstrations on four examples following a brief summary of the fundamental concepts of the method.

Integral Principle. Petroleum fractions may be regarded as continua (mixtures) of an indefinite number of hydrocarbon components, each appearing in an infinitesimal amount. On the true boiling point distillation curve for the mixture, each of these components will be a point, as contrasted to the plateaus that represent the finite amounts of components on the TBP curves of light hydrocarbon mixtures.

In distillation calculations for "finite" mixtures, the vapor-liquid distribution and properties of the equilibrium phases are found by the summations of component distributions and properties.

For continua (mixtures) of an indefinite number of components, the distillation calculations follow the same basic principles, but the "summation" becomes an "integration."

This distinction is illustrated by the following bubble point relationships:

$$\Sigma Kx = 1.0 \text{ for "finite" mixture} \quad (14.2)$$

$$\int_0^1 K dm_F = 1.0 \text{ for continuum} \quad (14.3)$$

For a mixture of finite components, the values of Kx are summed for all components. When the K values are taken at the correct bubble point temperature, this sum in unity.

For the continuum, an integration is performed by determining the area under a curve of K vs. m_F. The points for this curve are located by finding the values of K at the system temperature and pressure for each of several component points on the TBP curve. At the bubble point, the area under the K vs. m_F curve equals unity.

Points on the distillation curve of the bubble point vapor can be found in the integral procedure by finding the area under the curve up to the value of m_F in question. The ratio of this area to the total area under the K vs. m_F curve gives the value of m_V.

The same analogy between summations and integral procedure holds for the dew point and other distillation calculations.

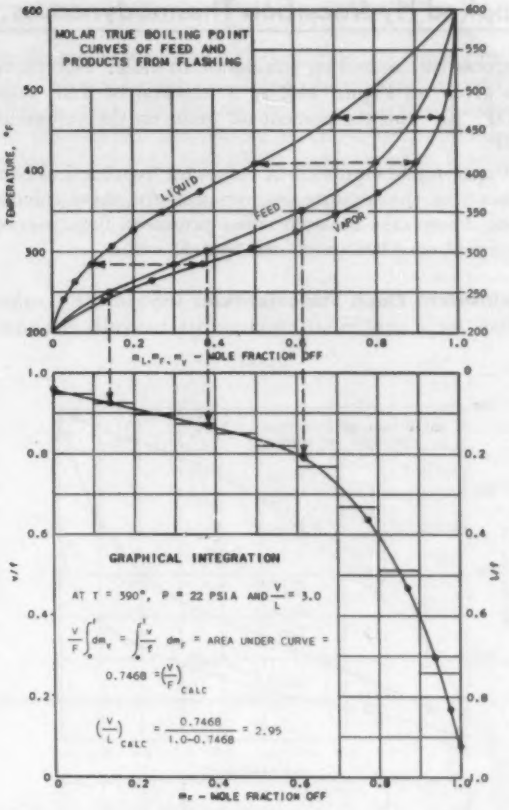
MOLAR TRUE BOILING POINT CURVES OF FEED AND PRODUCTS FROM FLASHING
TEMPERATURE, °F
LIQUID
FEED
VAPOR
m_L, m_F, m_V - MOLE FRACTION OFF
GRAPHICAL INTEGRATION
AT T = 390°, P = 22 PSIA AND $\frac{V}{L}$ = 3.0
$\frac{V}{F}\int_0^F dm_V = \int_0^F \frac{V}{F} dm_F$ = AREA UNDER CURVE =
0.7468 = $\left(\frac{V}{F}\right)_{CALC}$
$\left(\frac{V}{L}\right)_{CALC} = \frac{0.7468}{1.0-0.7468} = 2.95$
V/F
L/F
m_F - MOLE FRACTION OFF

FIGURE 14.3—Molar true boiling point curves of feed and products from flashing—Example 1.

FIGURE 14.4—Graphical integration for flashing—Example 1.

Component Ratios. The integral technique can be used in equilibrium flash vaporization calculations or fractional distillation calculations and may be applied to increments or components of any amount. In this way distillation calculations can be made for continua by computing the distribution ratios of several points, or infinitesimal components, and then finding the total by integration. In distillation calculations it is more convenient to use component ratios for designating the distribution of the infinitesimal components to the products, as illustrated later.

Data Requirements. The petroleum fraction must be defined by a molar TBP curve (i.e., temperature in ° F. vs. mole fraction of original mixture distilled) in this method. All calculations are based on this molar TBP curve and result in products defined by similar curves.

In the usual situation, TBP distillation data are expressed as temperature versus volume percent off. Figures 14.1 and 14.2 are used for converting the liquid volume TBP curve to a molar TBP curve. Instantaneous moles per 100 gallons are given in Figure 14.1 as a function of boiling point and gravity or UOP "K." Delta

percents for converting volumetric to molar TBP curves are given on Figure 14.2 as a function of TBP slope, UOP "K," and the percent off point on the volumetric TBP.

Vapor-liquid equilibria K values for hypothetical components of the mixture are required for these calculations. These may be from vapor pressures, fugacities, or empirical correlations of observed K values.

Equilibrium Flash Vaporization. Integral EFV calculations for a continuum mixture are basically the same as EFV calculations for a finite mixture. Both involve assuming an L/V ratio, looking up K values, finding component distribution to vapor and liquid, summing up to get total L and V, and finally checking the assumed L/V ratio.

The equations used in equilibrium flash vaporization are:

$$v/f = 1/(1 + L/KV) \quad (14.4)$$

$$l/f = 1/(1 + KV/L) \quad (14.5)$$

Since these equations give component distribution fractions, they can be applied to the components of finite mixtures or to the infinitesimal components of continua.

In the integral EFV calculation, values of v/f or l/f (= 1 — v/f) are found for several points along the molar TBP curve and plotted against m_F. The area under this curve gives vapor-liquid split for the entire mixture. If this checks the assumed L/V, the required equilibrium is satisfied.

The integral method differs from the finite component mixture in that calculations are made for several selected points on the molar-TBP curve and the totals are found by integrating under a curve.

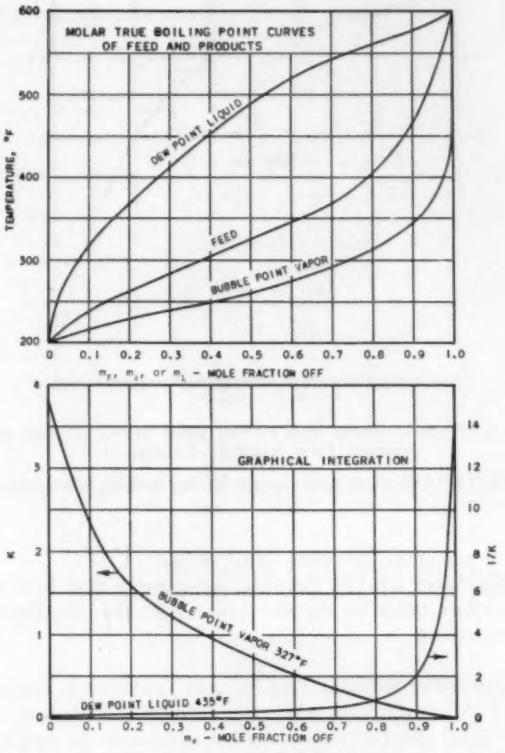

FIGURE 14.5—Molar true boiling point curves of feed and products for bubble and dew point calculations—Example 2.

FIGURE 14.6—Graphical integration for bubble and dew point calculations—Example 2.

TABLE 14.1—Conversion of Volumetric TBP to Molar TBP Curve for Example 1 by Use of Figure 14.1.

Liq. Vol. %	Gallons	t, °F	Ave. t°F	Moles/ 100 Gal.	Moles	Mole Fraction	Moles off
0		200					0
	10		223	6.15	0.615	0.1215	
10		247					0.1215
	20		269	5.70	1.140	0.2254	
30		291					0.3469
	20		312	5.33	1.066	0.2107	
50		334					0.5576
	20		360	4.96	0.992	0.1961	
70		387					0.7537
	20		438	4.38	0.876	0.1732	
90		490					0.9269
	10		545	3.70	0.370	0.0731	
100		600					1.0000
Σ					5.059	1.0000	

In the integral method, values of v/f or l/f (= 1 — v/f) are found for several points along the molar TBP curve and plotted against m_F. The area under this curve gives vapor-liquid split for the entire mixture. If this checks the assumed L/V, the required equilibrium is satisfied.

The integral method differs from the finite component mixture in that calculations are made for several selected points on the molar-TBP curve and the totals are found by integrating under a curve.

Example 1. Calculate the amount and composition of vapor and liquid from an equilibrium flash vaporization of a 39.6° API petroleum fraction at 390° F. and 22 lb/sq in. abs. with a TBP distillation as follows: 0% 200° F., 10% 247° F., 30% 291° F., 50% 334° F., 70% 387° F., 90% 490° F., and 100% 600° F.

Solution: Figures 14.3 and 14.4 illustrate the solution of this example. Calculation steps are described below:

Step 1—Convert the TBP volume percent to mole fraction and plot. Enter Figure 14.1 with the TBP 50% temperature of 334° F. and rise to 39.6° API. This is about 11.2 UOP "K." Values of moles per 100 gallons should be read along this UOP "K" line for other portions of the feed. This assumes that all portions of the feed have the same UOP "K." It should be noted that the UOP "K" determined from the TBP 50% temperature is the same UOP "K" which would be obtained from the equivalent ASTM 50% temperature.

The numerical calculations of Step 1 are given in Table 14.1. The temperatures in the third column vs. the moles off are plotted in Figure 14.3.

Step 1 (Alternate)—Table 14.2 shows the conversion of volumetric TBP to molar TBP by use of Figure 14.2. When this alternative is used the temperatures in the second column and the moles off in the fourth column are plotted as in Figure 14.3.

Step 2—Assume V/L, find K values for each 50° F. "component." K values given in Table 14.3 for this solution are from vapor pressures.

Step 3—Plot l/f or v/f vs. m_F. (See Figure 14.4.)

Step 4—Find area under curve and check assumed V/L. (See Table 14.4.) Area gives V/L = 2.95 vs. 3.0 assumed. This is a satisfactory check.

Step 5—At the 0.1 abscissa divisions on Figure 14.2, locate points on the vapor and liquid product curves relative to the feed curve in the manner shown by the horizontal dash lines and arrows, using values of prorated accumulated areas for the liquid and vapor from Step 4. The resulting vapor and liquid TBP curves vs. mole fraction off are then drawn through these points, as shown in Figure 14.3 for the flash at 390° F. and 22 psia.

Bubble and Dew Points. Bubble and dew point calculations for the integral method are the same, in principle, as bubble and dew point calculations for finite mixtures by the conventional methods.

The integral relationship for bubble point calculation is:

$$\int_0^{1.0} K dm_F = 1.0 \qquad (14.3)$$

Values of K at an assumed temperature for several points on molar TBP curves are plotted against m_F and the area under the curve found. An area of unity indicates the correct temperature assumption.

The integral relationship for the dew point calculation is:

$$\int_0^{1.0} dm_F/K = 1.0 \qquad (14.6)$$

Values of 1/K at an assumed temperature for several points on the molar TBP curve are plotted against m_F and the area under the curve found. An area of unity indicates the correct temperature assumption.

Bubble point calculations are sensitive to the front end K values, while dew point calculations are sensitive to the high boiling end K values. For these reasons, K values are found and plotted at more frequent intervals for the low boiling end in the bubble point calculations and at the high boiling end in the dew point calculations.

Example 2. For the same petroleum fraction in Example 1 find the bubble and dew point temperatures and distillations of equilibrium vapor and liquid at 22 psia using vapor pressure K values.

Solution. Figures 14.5 and 14.6 illustrate the solution of this example. Calculation steps are:

Step 1—Temperature is assumed, K values found for several hypothetical components (as defined by the temperature points on the molar TBP curve) and a plot of K (or 1/K) vs. m_F for each point being the value at component boiling point on the TBP curve. Both curves are shown on Figure 14.6.

Step 2—For the bubble point, the area under the K vs. m_F curve must equal unity. For a dew point, the area under the 1/K vs. m_F curve must equal unity. These areas can be found by means of a planimeter or by counting squares on graph paper, or by tabulation, as in Tables 14.5 and 14.6.

Step 3—The TBP curves of the bubble point vapor and dew point liquid can now be determined by plotting values of m_V and m_L from Tables 14.5 and 14.6 vs. temperature. (See Figure 14.5.)

Fractional Distillation. The integral technique can be applied to multistage distillation calculations, as well as to single-stage equilibrium flash vaporization. Component distribution calculations are made for infinitesimal portions of the feed to distillate and bottoms in the same

TABLE 14.2—Conversion of Volumetric TBP to Molar TBP Curve for Example 1 by Use of Figure 14.2

Liquid Volume Percent Off	TBP Temp., °F	△ Percent	m_F Moles Off
0	200	0	0
10	247	2.2	0.122
30	291	4.8	0.348
50	334	5.5	0.555
70	387	4.4	0.7440
90	490	1.8	0.9180
100	600	0	1.00

TABLE 14.3—Calculation of Separation Functions for Example 1 at $(V/L)_{assumed} = 3.0$

SEPARATION FUNCTIONS AT $(V/L)_{ASSUMED} = 3.0$

t, °F	K, 390°F, 22 psia	KVI/L	l/f	v/f
200	7.40	22.2	0.0431	0.9569
250	4.00	12.0	0.0769	0.9231
300	2.20	6.6	0.1316	0.8684
350	1.30	3.90	0.204	0.796
400	0.59	1.77	0.361	0.639
450	0.30	0.90	0.526	0.474
500	0.14	0.42	0.704	0.296
550	0.064	0.192	0.838	0.162
600	0.027	0.081	0.925	0.075

TABLE 14.4—Integration Calculations—Example 1

INTEGRATION CALCULATIONS

m_F	Mean Ordinate l/f	Mean Ordinate v/f	Liquid Areas Incr.	Liquid Areas Acc./Total	Vapor Areas Incr.	Vapor Areas Acc./Total
0				0		0
	0.054	0.946	0.0054		0.0946	
0.1				0.02133		0.1267
	0.0775	0.9225	0.00775		0.09225	
0.2				0.05193		0.2502
	0.1025	0.8975	0.01025		0.08975	
0.3				0.09242		0.3704
	0.1275	0.8725	0.01275		0.08725	
0.4				0.1428		0.4872
	0.1510	0.8490	0.01510		0.08490	
0.5				0.2024		0.6009
	0.1810	0.8190	0.01810		0.08190	
0.6				0.2739		0.7105
	0.2380	0.7620	0.02380		0.07620	
0.7				0.3679		0.8126
	0.3380	0.6620	0.03380		0.06620	
0.8				0.5014		0.9012
	0.5000	0.5000	0.05000		0.05000	
0.9				0.6988		0.9682
	0.7625	0.2375	0.07625		0.02375	
1.0				1.0000		1.0000
			0.2532		0.7468	

TABLE 14.5—Bubble Point Temperature Calculation at 327° F

t°F	m_F	△m_F	K 22 psia	Mean K	Area	Values of m_V = Acc. Areas for Bubble Point Vapor TBP
200	0		3.85			0
		0.060		3.24	0.1944	
225	0.060		2.63			0.1944
		0.080		2.30	0.1840	
250	0.14		1.98			0.3784
		0.120		1.72	0.2064	
275	0.26		1.45			0.5848
		0.120		1.24	0.1488	
300	0.38		1.02			0.7336
		0.24		0.755	0.1812	
350	0.62		0.49			0.9148
		0.17		0.356	0.0652	
400	0.79		0.222			0.9800
		0.09		0.161	0.0145	
450	0.88		0.100			0.9945
		0.055		0.0728	0.0040	
500	0.935		0.0455			0.9985
		0.038		0.0312	0.0012	
550	0.973		0.0168			0.9997
		0.027		0.0116	0.0003	
600	1.000		0.0064			1.0000

TABLE 14.6—Dew Point Temperature Calculation at 435° F

t°F	m_F	△m_F	$\frac{1}{K}$ 22 psia	Mean $\frac{1}{K}$	Area	Values of m_L = Acc. Areas for Dew Point Liquid TBP
200	0		0.0936			0
		0.14		0.1283	0.0180	
250	0.14		0.1630			0.0180
		0.24		0.2225	0.0534	
300	0.38		0.2820			0.0714
		0.24		0.3880	0.0931	
350	0.62		0.494			0.1645
		0.17		0.7035	0.1196	
400	0.79		0.913			0.2841
		0.05		1.085	0.0542	
425	0.84		1.257			0.3383
		0.04		1.508	0.0603	
450	0.88		1.760			0.3986
		0.03		2.130	0.0639	
475	0.91		2.500			0.4625
		0.025		3.024	0.0756	
500	0.935		3.548			0.5381
		0.020		4.302	0.0860	
525	0.955		5.057			0.6241
		0.018		6.146	0.1106	
550	0.973		7.236			0.7347
		0.017		8.323	0.1415	
575	0.990		9.410			0.8762
		0.010		12.38	0.1238	
600	1.000		15.35			1.0000

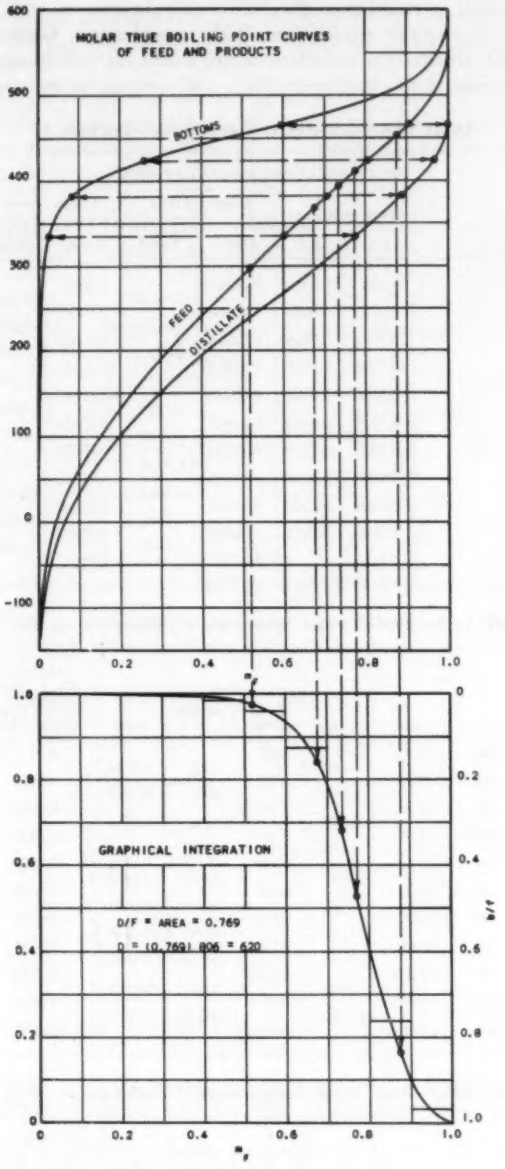

FIGURE 14.7—Molar true boiling point curves of feed and products of fractional distillation—Example 3.

FIGURE 14.8—Graphical integration for fractional distillation calculations—Example 3.

way that such calculations are made for mixtures of finite components.

Ratio type of component distribution equations for multicomponent, multistage fractionation are given in terms of absorption and stripping factors.

For the enricher:

$$l_n/d = A_0A_1A_2A_3 \ldots A_n + A_1A_2A_3 \ldots A_n + A_2A_3 \ldots A_n + \ldots + A_n \quad (14.7)$$

For the exhauster:

$$v_m/b = S_0S_1S_2S_3 \ldots S_m + S_1S_2S_3 \ldots S_m + S_2S_3 \ldots S_m + \ldots + S_m \quad (14.8)$$

For meshing:

$$d/f = \frac{v_m/b + v_f/f}{l_n/d + v_m/b + 1} \quad (14.9)$$

$$b/f = \frac{l_n/d + l_f/f}{l_n/d + v_m/b + 1} \quad (14.10)$$

where v_f/f and l_f/f are component distribution ratios for feed flashing and subscripts designate plate location numbering from terminals (top and bottom) toward the feed.

$A = L/KV = 1/S$, $A_o =$ (for total condenser)

The above component distribution ratio equations represent one of several ways that such calculations can be made. These equations are not part of the integral technique. The component distribution ratios might be found by a short-cut method if desired.

After separation functions are evaluated and component distribution ratios found, by these or other equations, the values of d/f or b/f are plotted against m_F. The area under this curve gives D/F and B/F. Areas up to different values of m_F are used to determine points on molar TBP of products.

An interesting feature of the integral method, as applied to fractional distillation, is that distribution ratios are estimated for several closely spaced points near the cut point and at a few widely spaced points on the balance of the curve.

Example 3. A gasoline rerun column, consisting of a reboiler and one theoretical plate below the feed and two theoretical plates and a total condenser above, will be used to illustrate the application of the integral technique in fractional distillation. In this problem the feed stock is defined by a true boiling point distillation curve, the reflux and boil-up are fixed, and the problem is to calculate the products.

The problem is from Thiele-Geddes,[38] and is the same problem previously[8] used to illustrate the integral method. The present solution is simpler. The temperatures and quantities of vapor and liquid given by Thiele-Geddes for each plate are used in the following solution.

Solution. This calculation is identical to the flash calculation except in the evaluation of the separation functions. The effects of the number of theoretical stages and the reflux must be included. The separation function must be evaluated for the equivalent hydrocarbons in the vicinity of the cut point, however, because of the sharpness of separation.

These separation functions are based upon an assumed temperature gradient and assumed liquid and vapor traffics from plate to plate. Thus, the calculations give the products from the assumed operation. Figures 14.7 and 14.8 illustrate the solution.

Calculations giving the d/f value for each component are plotted at the proper value of m_F and the area under the curve found. This equals D/F from which D is found and the desired over-all stock balance checked.

Product TBP curves are plotted with points obtained from the areas up to various m_F values. The numerical and graphical parts of this operation are shown. Following is the step-by-step procedure.

Step 1—Plot molar TBP curve for feed, deriving points for this curve from the volumetric TBP and Figure 14.1 or 14.2 if necessary. See Figure 14.7 for resulting plot.

Step 2—Assume number of plates, temperatures, and liquid and vapor quantities (given by Thiele-Geddes in this case).

Step 3—Select several component points and evaluate sepa-

ration functions. This is done in Table 14.7.

Step 4—Plot d/f values from Step 3 against m_F in Figure 14.8.

Step 5—Integrate, finding area under curve in Figure 14.8. This is equal to D/F giving D = 620, which checks material balance.

Step 6—Find areas under curve in Figure 14.8 up to different values of m_F and from these estimate molar TBP curves of products. (See Table 14.8 for calculations and Figure 14.7 for curves.)

In most problems the temperatures and quantities of vapor and liquid will not be known at the beginning. These must be assumed before the above calculations can be made. These assumptions may then be checked by computing the quantities and assays of intraplate vapor and liquid streams, using the product quantities and t vs. m curves from the previous calculations.

Batch Distillation. Simple batch distillation is a differential process because vapors are removed as they are formed. Solution of batch distillation problems for a mixture known by its molar true boiling point curve is most easily accomplished by use of the integrated form of the Raleigh equation and a trial and error integral method.

The integrated Raleigh equation is:

$$(X''/X')_1 = (X''X')\alpha_n \qquad (14.11)$$

where $\alpha = K_1/K_n$

(X''/X'), for a component, is the ratio of moles in the liquid after distillation to the moles in the liquid before distillation. The relative volatilities should be constant over the temperature range but an average value may be used.

The method of solution consists of assuming a final temperature (for a constant pressure distillation) and fixing the ratio X_2/X_1 for one point on the molar TBP curve. Then ratios of X_2/X_1 for other points on the TBP curve are calculated. The new mole fraction in the remaining liquid for any point on the molar TBP curve is:

$$\frac{\int_0^{\text{old m.f.}} (X''/X')\,dx}{\int_0^1 (X''/X')\,dx} \qquad (14.12)$$

The assumed temperature is correct for the fixed X''/X' if $\int_0^1 K\,dx = 1$ where x is the mole fraction in the remaining liquid. If $K = p^\circ/P$ then $\int_0^1 p^\circ\,dx = P$.

Example 4. Determine the volume of fuel lost if an airplane rises from sea level to 52,000 feet. Assume the fuel remains at 100° F and is vented to the atmosphere.

The fuel has a specific gravity of 0.745, Reid Vapor Pressure of 2.86 lb., and an ASTM D 86 distillation as follows: IBP 113° F, 5% 180° F, 10% 192° F, 15% 202° F, 20% 210° F, 25% 219° F, 30% 225° F, 40% 240° F, 50% 257° F, 60% 280° F, 70% 310° F, 80% 350° F, 90% 410° F, 95% 457° F, EP 480° F. Loss 1% and residue 1%.

Solution. This is a batch or differential distillation at 52,000 feet. The assumption that the temperature remains at 100° F requires heat input to the fuel tank equal to the removed latent heat of vaporization.

Step 1—Plot ASTM D 86 temperatures vs. liquid volume percent off. (Percent off equals percent collected plus distillation loss.)

Step 2—Convert ASTM D 86 curve to a TBP curve by means of Figure 12.5.

Step 3—Convert the volumetric TBP curve found in Step 2 to a molar TBP curve by the top part of Figure 14.1. See Figure 14.9.

Step 4—Calculate the vapor pressure of the original fuel at 100° F by finding the area under a curve drawn through several vapor pressure points plotted against the corresponding mole percent distilled on the TBP curve. This calculated vapor pressure is compared with the given RVP to check the two conversions, ASTM to TBP and volume percent TBP to mole percent TBP. See Figure 14.10.

Step 5—Find relative volatilities of hydrocarbons corresponding to various points along the TBP curve using octane as the reference component.

Step 6—Assume the ratio of any one component in the liquid before and after the distillation. Compute similar ratios for other components from relative volatilities using the relationship:

$$(X''/X')c_n = (X''/X')\alpha c_8$$

Plot these vs. mole percent off. See Figure 14.11.

Step 7—Check the assumption in Step 6 by plotting vapor pressure vs. new mole percent (lower curve in Figure 14.10) finding the new mole percent from the prorata areas under the Figure 14.11. If the resulting vapor pressure equals the atmospheric pressure at the altitude, then the assumption of Step 6 was correct.

Step 8—Calculate liquid volume loss by converting the molar loss curve (Figure 14.11) to a liquid volume loss curve and find the area under the curve. On the same graph plot the gallons per mole of original fuel and find the area under the

TABLE 14.7—Separation Functions—Example 3

SEPARATION FUNCTIONS

Equivalent H—C. Atm BP °F	C_9 298	C_{11} 360	C_{12} 393	C_{13} 415	C_{15} 453
Reboiler: t = 435°F, L = 196, V = 1079, V/L = 5.5					
K	5.18	2.25	1.697	1.316	0.789
S_0 = KV/L	28.5	12.4	9.33	7.24	4.34
Plate 1: t = 365°F, L = 1275, V = 818, V/L = 0.642					
K	2.4	0.934	0.667	0.486	0.279
S_1 = KV/L	1.54	0.5996	0.428	0.312	0.179
Plate 2: t = 355, L = 208, V = 822, L/V = 0.253					
K	2.14	0.816	0.575	0.414	0.237
A_2 = L/KV	0.1182	0.310	0.440	0.611	1.066
Plate 3: t = 322, L = 212, V = 822, L/V = 0.258					
K	1.38	0.492	0.337	0.238	0.130
A_3 = L/KV	0.187	0.524	0.765	1.083	1.981
Enriching with reflux from total condenser: R = 0.3475					
A_3 (1 + R)	0.252	0.706	1.031	1.459	2.669
A_2 [1 + A_3 (1 + R)] = ln/d	0.148	0.5288	0.8936	1.503	3.912
Stripping					
S_0 + 1	29.5	13.4	10.33	8.24	5.34
S_1 (S_0 + 1) = v_m/b	45.6	8.03	4.43	2.57	0.955
Feed Plate Mesh					
ln/d + v_m/b + 1	46.75	9.56	6.32	5.07	5.86
$\frac{d}{f} = \frac{v_m/b}{\ln/d + v_m/b + 1}$	0.975	0.839	0.701	0.487	0.163

TABLE 14.8—Integration Calculations—Example 3

	INTEGRATION CALCULATIONS						
	DISTILLATE				BOTTOMS		
m_F	Mean Ordinate	Incr. Areas	Prorated Incr.	Acc. Prorated	Incr. Areas	Prorated Incr.	Acc. Prorated
0				0			0
	0.9999	0.09999	0.1306		0.00001	0.0001	
0.1				0.1306			0.0001
	0.999	0.0999	0.1303		0.0001	0.0004	
0.2				0.2609			0.0005
	0.998	0.0998	0.1293		0.0002	0.0009	
0.3				0.3902			0.0014
	0.995	0.0995	0.1290		0.0005	0.0022	
0.4				0.5193			0.0036
	0.986	0.0986	0.1282		0.0014	0.0060	
0.5				0.6475			0.0096
	0.960	0.0960	0.1248		0.0040	0.0173	
0.6				0.7723			0.0269
	0.875	0.0875	0.1138		0.0125	0.0541	
0.7				0.8861			0.0810
	0.600	0.060	0.0780		0.0400	0.1730	
0.8				0.9641			0.2540
	0.240	0.024	0.0312		0.0760	0.3290	
0.9				0.9953			0.5830
	0.036	0.0036	0.0047		0.0964	0.4170	
1.0				1.0000			1.000
		0.76889	1.000		0.23111	1.00	

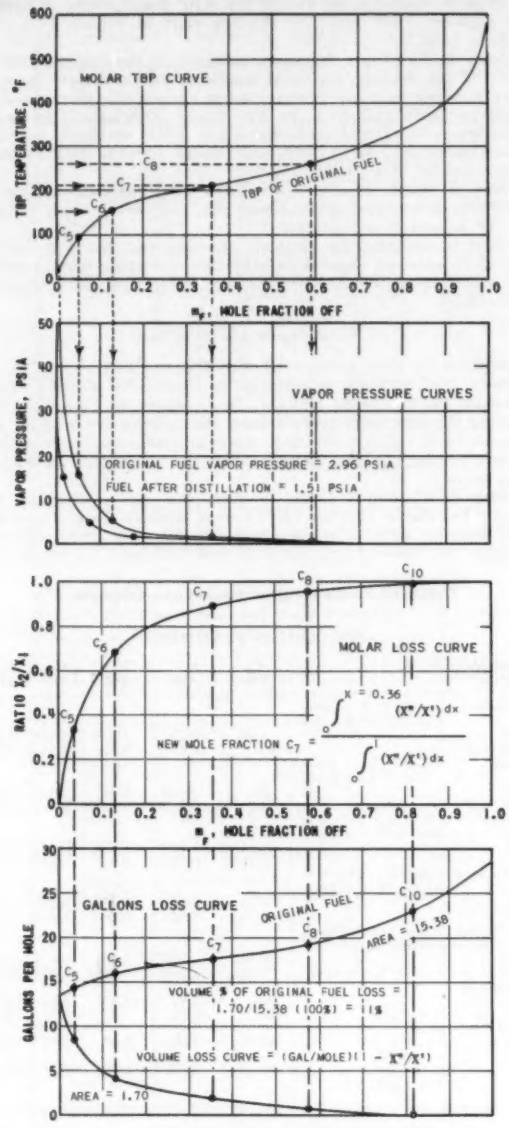
MOLAR TBP CURVE
TBP TEMPERATURE, °F
TBP OF ORIGINAL FUEL
m_F, MOLE FRACTION OFF
VAPOR PRESSURE CURVES
VAPOR PRESSURE, PSIA
ORIGINAL FUEL VAPOR PRESSURE = 2.96 PSIA
FUEL AFTER DISTILLATION = 1.51 PSIA
MOLAR LOSS CURVE
RATIO X_F/X_I
NEW MOLE FRACTION C_7 = $\int_0^{X=0.36} (X''/X')\,dx \Big/ \int_0^{1} (X''/X')\,dx$
m_F, MOLE FRACTION OFF
GALLONS LOSS CURVE
ORIGINAL FUEL
AREA = 15.38
VOLUME % OF ORIGINAL FUEL LOSS = 1.70/15.38 (100%) = 11%
VOLUME LOSS CURVE = (GAL/MOLE)(1 − X''/X')
AREA = 1.70
GALLONS PER MOLE

FIGURE 14.9—Molar TBP curve for batch distillation calculations—Example 4.

FIGURE 14.10—Vapor pressure curves for batch distillation calculations—Example 4.

FIGURE 14.11—Molar loss curve for batch distillation—Example 4.

FIGURE 14.12—Gallons loss curve for batch distillation—Example 4.

curve. The loss is then the ratio of these two areas or 11%. See Figure 14.12.

NOMENCLATURE

L = moles of liquid mixture
V = moles of vapor mixture
F = moles of feed mixture
D = moles of distillate mixture
B = moles of bottoms mixture
l = moles of any infinitesimal increment* of the liquid
v = moles of any infinitesimal increment* of the vapor
f = moles of any infinitesimal increment* of the feed
d = moles of any infinitesimal increment* of the distillate
b = moles of any infinitesimal increment* of the bottoms
$K = y/x$ = vapor-liquid equilibria ratio
$\alpha = K_2/K_1$ = relative volatility
y = mole fraction of infinitesimal increment* of the vapor
x = mole fraction of infinitesimal increment* of the liquid
X = moles of component in liquid
$A = L/KV$ = absorption factor on indicated equilibrium stage
$S = \frac{KV}{L}$ = stripping factor on indicated equilibrium stage
m_F = mole fraction off at indicated temperature in true boiling point analytical distillation of feed
m_L = mole fraction off at indicated temperature in true boiling point analytical distillation of liquid product
m_V = mole fraction off at indicated temperature in true boiling point analytical distillation of vapor product
M = moles of mixture
P = pressure
p^o = vapor pressure
T_B = boiling point, °R
R = reflux ratio, i.e., moles of reflux to moles of distillate

* An indefinite number of these infinitesimal increments (or components) make up each petroleum fraction.

SUBSCRIPTS

O refers to reboiler or condenser
1, 2, 3, etc., indicate equilibrium stages numbered from condenser or reboiler toward the feed plate
n refers to bottom plate in enriching section
m refers to top plate in stripping section
f refers to feed
i and n designate any component

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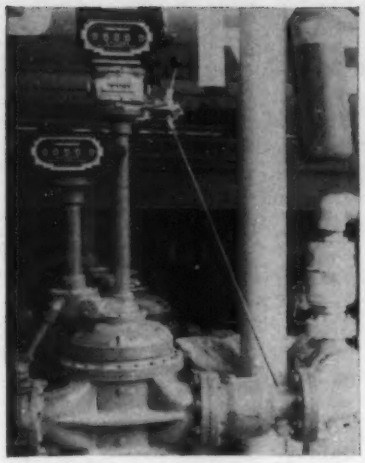


FIGURE 1—Positive displacement meter with pre-set counter and set-stop valve controls amount of product being loaded.

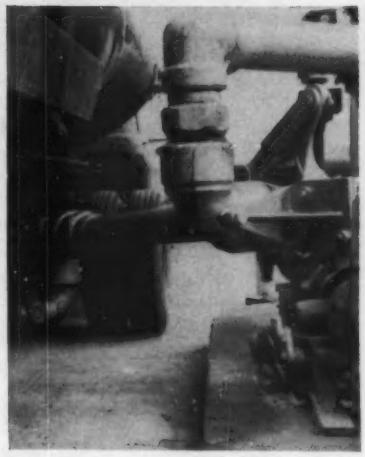


FIGURE 2—Aluminum swing arm and quick coupling, self-sealing valve connect truck and loading facilities.

FIGURE 3—Loading is convenient because it is done from the ground with all control devices at the same level.

Bottom-Loading Tank Trucks Successful

System will be adopted industry-wide in the future. It is the safe, fast, sound and practical method of loading modern road transports

W. L. Hunter
The Pure Oil Company, Chicago

CONTRARY to public opinion, the loading of petroleum transport trucks through the bottom is not altogether a new concept. Numerous oil companies, both in this country and in Europe, have experimented with this idea for a number of years, but until recently, there seems to have been little real progress.

Almost all companies are faced with the problem of loading racks which cannot accommodate the increasing height of new transports or providing loading racks with the necessary facilities to permit safe loading of transports with variation in height.

Bottom loading has been introduced by The Pure Oil Company to counteract the rising construction and maintenance costs on conventional loading racks and to improve safety in loading petroleum products. The equipment being installed is simple when compared with the platforms, steel structure, loading assemblies, bonding equipment and miscellaneous items which are needed when loading over-the-top.

Systems. The principle of bottom loading is good in itself, but to obtain its full advantages, it is necessary to have a system which will control automatically the loading of compartments with the required quantity. One of the primary objectives of the early experimental and trial installations was to develop a device to automatically control quantity of product loaded, with a degree of reliability. One of the more practical systems uses the positive displacement meter which controls the quantity of product loaded by its pre-set counter and set-stop valve (Figure 1). A second system has a control device located in the transport which produces a signal for an automatic shut-off device located on the loading island. The third system has the complete control mechanism built in each compartment of the transport to automatically close off the entering flow.

Experience has indicated that the degree of control required can be obtained by utilizing the existing metering equipment. Meter manufacturers developed pre-set counter and set-stop valves as accessories to their meters to control quantities of products desired in compartments when loading at a conventional loading rack. This same equipment when applied to bottom loading offers a reliable method of operation. Experience to date has indicated that no greater number of overflows occurs in bottom loading than in the conventional over-the-top method when controlled from a positive displacement meter. One of the early complete bottom loading systems made available to the petroleum industry had the control device located in the compartments of the transport and the automatic shut-off device located at the loading area. Sensing tubes located inside the compartments produced a signal through coupled tubing to a diaphragm actu-

ated valve which provided automatic control.

There are various systems now available which can be installed within each compartment to obtain automatic shut-off of loading flow. The compartment bottom valve normally performs the combined function of automatic shut-off and emergency valve. An internal float control system is used to actuate the balanced valves to obtain the shut-off. Experimental work has also been performed on a system which uses a Venturi in the flow line to produce a vacuum which is used in the controlling system.

Loading Islands. A practical arrangement of bottom loading facilities consists of loading islands which are approximately 16 feet in length and 6 feet in width. Four products can be handled on each island which may consist of two gasolines and two heating oils. All piping for the various products is normally 4-inch including meters and set-stop valves. The systems are designed and operate at a 500-gpm loading rate. The connection between transport and loading island is obtained through a 3-inch aluminum swing-arm arrangement. A 3-inch quick coupler valve is used on the end of the loading assemblies which connects with the mating portions of valve on the transport. This system will permit a 7,000 gallon transport to be loaded in about 15 minutes.

Quick Coupling Valves. Until a few years ago the main problem confronting bottom loading was the making and breaking of the filling connection without appreciable spillage. The product spilled at the loading area was not only a loss, but a fire hazard. In some cases special piping was used to empty the line before disconnecting. It was not until the advent of the self-sealing coupling that bottom loading could be considered a practical method (Figure 2).

Savings. What are the savings to be realized from bottom loading? A conventional four-product loading rack installed is estimated to cost about $40,000. Bottom loading facilities installed to handle the same number of transports is estimated to cost about $24,000, or a savings of approximately 40 percent. Simplifying the loading system and eliminating the overhead structure have made this savings possible. At the same time greater utilization of loading area is obtained, variation in transport height does not affect operation, and less maneuvering of vehicles is required.

Improved Efficiency. The full advantages of bottom loading are obtained as it becomes a one-man operation, carried out fast, safely and automatically from the ground (Figure 3). The availability of equipment to obtain self-venting of the transport has assisted in fulfilling the requirements. The arrangement of bottom loading facilities permits both the operating devices of the transport to be at the same level and location as loading equipment, an advantage which has been hereto unattainable. Less equipment is handled, and once coupled up, loading can be switched from one compartment to another by turning valves. All compartments are filled through a single connection, eliminating re-spotting of transport as occurs at an overhead loading rack. The present design of bottom loading facilities has been limited to 500 gpm; however, we foresee future facilities with loading rates of 750 gpm. The same loading rates being obtained by the conventional over-the-top method can and will be obtained in bottom loading.

About the Author

W. L. Hunter is a senior engineer in the General Engineering Department of The Pure Oil Co. He graduated from Northwestern University with a B.S. degree in mechanical engineering. He has served in various capacities with Pure, which included assistant superintendent of maintenance and engineering. Hunter is a member of ASME, ISA and API.

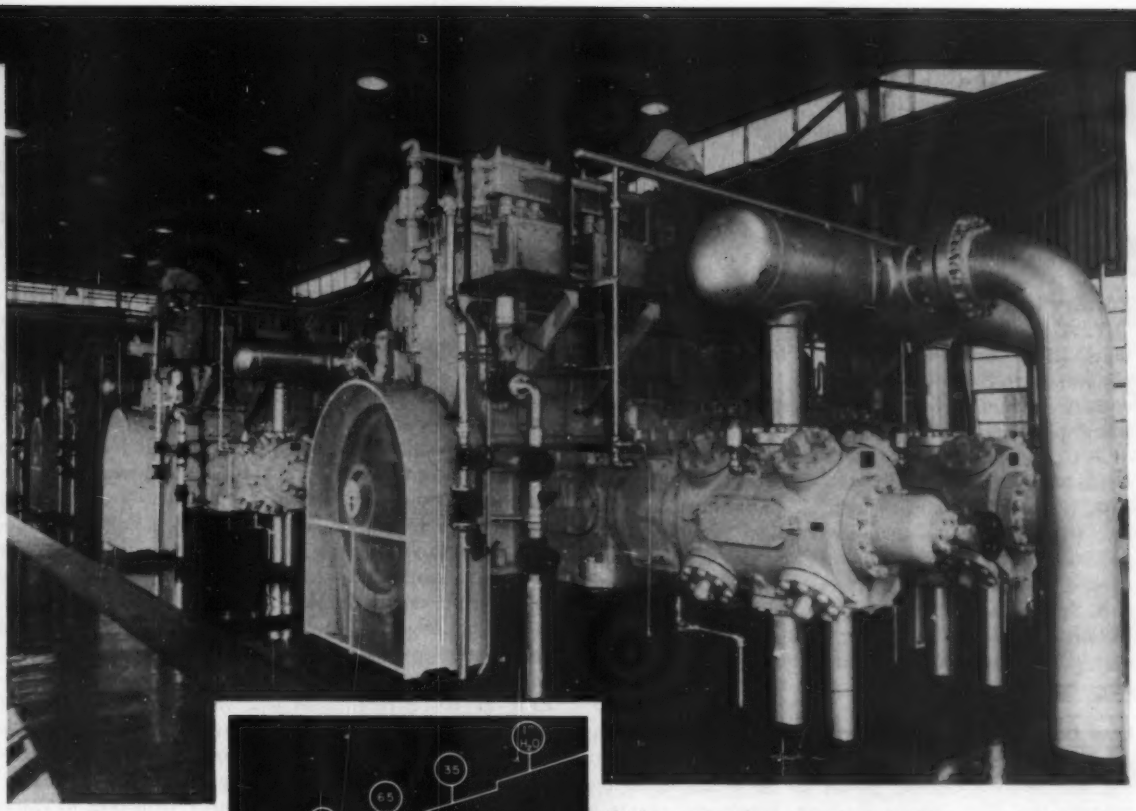
Grounding. Static grounding is automatic as soon as the connection is made, eliminating the cost of grounding equipment and the problems of drivers not carefully attaching bonding cable. The potential hazard of static electric charges causing explosion is reduced by the completely submerged loading. This is of major importance in the handling of jet fuel, naphtha, kerosine, and some heating oils.

Safety. Bottom loading, being a closed system, eliminates fumes being discharged in the vicinity of the loader. All of the required operations in bottom loading are performed at ground level eliminating accidents which occur from the top of transports. These accidents have been fortunately rare; however, they are severe or even fatal. Personnel at ground level are not subjected to possible injury which can result from a hasty scramble from the top of a transport in the case of fire or explosion. Crossing between loading rack platform and top of transport, handling heavy loading assemblies and operating loading valves have always been potential hazards which are eliminated.

Reduces Loss. There is a saving in vapor conservation during the loading operation since all loading is submerged, turbulence is minimized and venting may be under a slight pressure. Tests have indicated an average of 2.25 gallons is saved per 6,000 gallons of gasoline loaded.

Problems of Bottom Loading. It is a change from the "traditional" way of loading a transport and is subjected to normal resistance of "change." It requires a completely new method of operation together with new operating procedures and safety regulations.

Transports, which operate from bottom loading facilities, must be equipped with quick coupling self-sealing valves. It is usually desirable to install compartment venting which may require welding on the tank truck. However, if venting is not installed, transport can be loaded very successfully if driver unlocks dome covers before loading. ##



Fuel gas to engines goes through these pressure reductions.

PART 4 – Engine and Compressors

Operator's Handbook for Gasoline Plants

One of a series that simplifies operations and equipment for the new and experienced operator in a natural gasoline plant

Manufacturing Department
Bay Petroleum Company, A Division of
Tennessee Gas Transmission Co., Houston

COMPRESSORS ARE NEEDED in natural gasoline plants to bring feed gas up to process pressure or to compress low pressure gas streams later in the process. They are sometimes needed to bring residue gas up to pipeline pressure specifications or up to reservoir injection pressure.

Usually, these compressors are gas engine driven. Frequently, one engine will furnish enough power to compress more than one low pressure stream. So, the size and service of each compressor attached to an engine may be different.

For extremely low pressure gas, it is not practical to compress the gas up to the desired pressure in one step. Rather, the total compression of the gas occurs in two compressor cylinders; technically speaking, there is two stage compression of the gas. The first stage compresses the low pressure gas to an intermediate pressure and the second stage compresses this gas to the necessary high pressure.

All gas engines include four basic operating systems:

IGNITION

Ignition of a spark in the gas engine is the heat needed to start combustion within the cylinder.

Most engines in gasoline plants are spark ignited.

Spark ignition can be generated by a battery, low or high tension magneto, or impulse generator.

Battery ignition. It consists of:

1. A low voltage battery for power supply, 6 to 45 volts. (This can also be achieved by transforming supply voltage to the lower voltage.)

2. A distributor for synchronizing the spark with the power piston by use of breaker points.

3. Condenser to store the surge of primary current while the points are broken.

4. High tension coil to increase the voltage from the low (6 to 45 volts) primary voltage to high voltage (45,000 to 60,000 volts), thereby creating the hot spark needed to ignite the fuel mixture.

5. Spark plug to ignite the fuel.

This ignition system is used on the fire pump engines and some water pump engines, but is not a common large engine type of ignition.

Low tension magneto ignition, when placed on an engine, is a self-contained unit. The magneto, generating low tension electric power of 12 to 24 volts, distributes this low voltage through interrupter points to the primary winding on high tension coils located at each spark plug. These coils generate a spark at 45,000 to 60,000 volts. These coils transform the low voltage to the high voltage needed to jump the gap of the spark plug. This type of ignition system includes essentially the same parts as the battery type except that it is capable of generating the required supply of low tension electricity. Advantages of this type of ignition are:

1. Separate coil for each cylinder results in short high tension lead from coil to spark plugs.

2. Distribution of low tension current through the distributing system of the wiring and magneto.

3. Self-contained source of power.

High tension magneto ignition is similar to the low tension magneto in that it also generates the power supply within the unit. The difference is that it has the high tension coil within the magneto. The low tension current is stepped up and in turn distributed to the spark plugs by high tension wire. In this type, distributing or timing with high tension electricity occurs within the magneto. Working under high voltage within the magneto requires more upkeep on parts such as slip ring brushes, distributor cap, and coil.

The impulse generator system generates a high tension impulse directly from the generator and does not depend on breaker points or a distributor. These high tension impulses are timed and synchronized with the power piston for proper combustion.

FUEL SYSTEMS

Fuel systems in most plant operations use natural gas. This fuel comes from numerous places about the plant: residue gas after the absorbers, demethanizer overhead, purchased gas, or a combination of these.

Fuel systems should operate at a pressure and volume large enough to carry the peak load demand. The fuel supply should be clean—free of dirt, oils, and harmful elements such as sulfur, carbon dioxide, water, etc. The source of the fuel should be arranged so that a near constant Btu content is maintained. A change up or down in the Btu content will cause engines to run rich or lean.

Let us visualize a complete average plant fuel system. Assume the gas supply comes from the residue gas stream at 800 psig, reduced to 250 psig, then taken to a central point in the plant and reduced again to 65 psig. At this pressure it is distributed to the various points of consumption.

In the header for two cycle engines it is reduced to 15 to 35 psig depending on the type and size of engine. At the four cycle engines it is reduced to 4 to 8 ounces into a volume tank or large fuel header. Further reduction to a slight positive pressure of one inch of water or less is maintained at another volume tank just before entering the engine fuel-air mixing valve.

The 65 psig fuel gas will also go to the boilers and any heaters or other uses it may service at this pressure. Most boiler and heater burners will fire more economically at 10-12 psig. This will vary with the different brands and styles of burners. Further reduction to this pressure is made by the installation of temperature controlling motor valves in the fuel gas line.

Fuel systems should have adequate drip pots to catch any fluids that may collect or be drawn into the system. Without these pots or scrubbers, liquids drawn into the system become a potential source of trouble.

For the two-cycle engine, the fuel pressure is reduced to 15 to 35 psig and taken directly to the fuel injection valves located in each cylinder. By a camming system, the gas is injected directly into the cylinder and mixed with the fresh charge of air that has been forced into the cylinder by the fresh air scavenger system. This injection takes place just at the start of the compression stroke of the power piston. The compression stroke has started; therefore, the fuel injection pressure will vary from 15-35 psig, according to the various make, size, and type of engines, to provide the proper fuel air mixture in the cylinder.

The low pressures required for four-cycle engines have altogether a different function. Gas is delivered to the fuel air mixing valve at or near atmospheric pressure and drawn into the engine with the proper amount of air by the downward or loading stroke of the power piston. The air fuel mixing valve of the four-cycle engine is an adjustable ported or shutter type valve having ports that will move to change the ratio of fuel gas to air. These valves may be described as fuel mixing valves, carburetors, proportioning valves, etc., but they all serve the same purpose.

LUBRICATION

Proper lubrication of plant engines is essential for these reasons:

1. To reduce friction between moving parts.

2. To cool or carry away heat from moving parts.

3. To resist corrosion.

Reducing friction is the most important function that lubrication performs. Lubrication is applied in practically every piece of machinery that has moving parts. The lubricant is the micro-thin film of substance (usually oil) holding the metal parts apart, thus reducing friction and absorbing shock.

The amount of cooling accomplished by a lubricant is greater in some engines than in others. The oil is constantly removing heat from the bearings, heads of the pistons, and from side walls of the engine itself. The heat is transferred to cooling water in the oil coolers and dissipated to the atmosphere. The oil then returns to the engine for another cycle. The same process holds true for many pumps, motors and other equipment.

A lubricant also will protect the working parts from rust or other forms of corrosion. Ball and roller bearings, exposed sliding or rotating shafts, and cavities in and around the engine not protected by the oil splash of the crankcase are usually best protected by applying a heavy grease.

Lubrication manuals and charts should be prepared for each plant. Charts in such a manual outline the lubrication duties of the personnel for each piece of equipment in the plant.

This information should be included in each manual:

1. General instructions and responsibilities of people involved in lubrication.

2. A list of the lubricated equipment giving manufacturer, type, size, and equipment name of each item.

3. Lubricating instructions for operating personnel.

4. Lubricating instructions for mechanical personnel.

These instructions should give a detailed description of the procedure to be used in properly lubricating the equipment. It is impractical, of course, to give instructions on each pump, motor, etc. separately, so similar equipment requiring the same type lubrication are grouped together.

Gas engines are designed with a large oil reservoir in the bottom of the case. A gage glass is attached to the side of the case to indicate the oil level. The bearings are lubricated by an oil pump which is usually mounted on the engine shaft. This pump takes suction from the reservoir and pumps oil through a filter and cooler to the various bearings, gears, chains and other moving parts. The oil then drops back into the reservoir and the cycle repeats. Forced-feed lubricators are used to supply oil to the power and compression cylinders and piston rod packing on compressor engines. The oil level in the crankcase should be checked often to make sure the proper level is being maintained. The forced-feed lubricator should be filled once a shift or once a day as the schedule may be.

Filters for crankcase oil fall in two classifications: replaceable element type or multiplate type.

The replaceable element type contains a filtering material which removes the sludge and carbon from the oil. A clean filter will have a reasonably low (5 psig) pressure drop across it; but as sludge and carbon are picked up, the pressure drops across the filter will increase. The filters should be changed when the pressure drop gets to 15 psig, since excessive pressure drop will cause the bypass valve to open and the filter no longer serves its purpose.

The multiplate filter is made of very thin plates. Half of the plates are stationary and remove sludge and carbon from the oil as it flows between the plates. The other half of the plates slide between the stationary plates and dislodge the sludge and carbon which has been collected. These filters are cleaned by rotating the handles on the filter one complete turn each shift. If the filter is stiff from accumulated sludge, work the plates back and forth several times until they work freely. Filtering the oil removes foreign matter and increases the life of an oil; however, there are limiting values of viscosity and acid content that determine when an oil is to be discarded. Samples are periodically checked by the laboratory which recommends when an oil should be discarded.

Proper containers and facilities for storing lubricants are essential for good lubrication. One of the principal causes of bearing failure is foreign material, such as grit, dirt, rags, water, etc. finding its way into the oil or grease. Usually this foreign material gets into the lubricant during storage. To prevent this, containers should be covered at all times and kept in special cabinets. This is one more reason for having good housekeeping around a plant. Drums containing oil or grease should either be mounted on racks which allow them to be turned on their side, or tilted. This keeps water from entering the drum. They can be kept in the vertical position if a tight fitting drum pump is used.

COOLING

Engine cooling is a very important cooling function. Heat generated by combustion, bearing friction, etc., must be removed in order for the engine to keep operating. Engine cooling can be classed in three types:

1. Open cooling system.

2. Closed cooling system.

3. Vapor phase or ebullition cooling system.

The open-type cooling system is the simple operation of pumping water from a tank, spray pond, or stream through the jackets of the engine and back to the source. This type of cooling system is not satisfactory for the modern day engine. These systems have no control of temperature, dirt, or scale. They have been used in the past, but very few are in use today.

The closed cooling system consists of a jacket water pump, cooling coils in a cooling tower basin, air exchange fintube coolers with a fan, or shell and tube heat exchanger. This system will also have a shell and tube heat exchanger on the oil system of each engine to cool the oil. With the proper controls applied, this system will maintain the desired jacket water and oil temperatures. Water treatment of these systems is easy, as they need little make-up water.

Desired water temperatures on closed systems may be determined by each plant. Water inlet temperature on internal combustion engines will range from 140° F. to 180° F. The normal temperature rise of the cooling water through the engine is approximately 10° F. If a certain inlet temperature is set, the outlet temperature will have to be controlled by the velocity or speed the water travels through the engine. The more the velocity, the less the temperature rise.

Controls for this type system consists of controllable pitch fans; or in the case of shell and tube heat exchangers, motor valves to control the cooling tower water through the exchanger. These controls will be set at a given temperature of 160° F., for example. The temperature rise through the engine jackets will be controlled by a motor valve in the water outlet line to con-

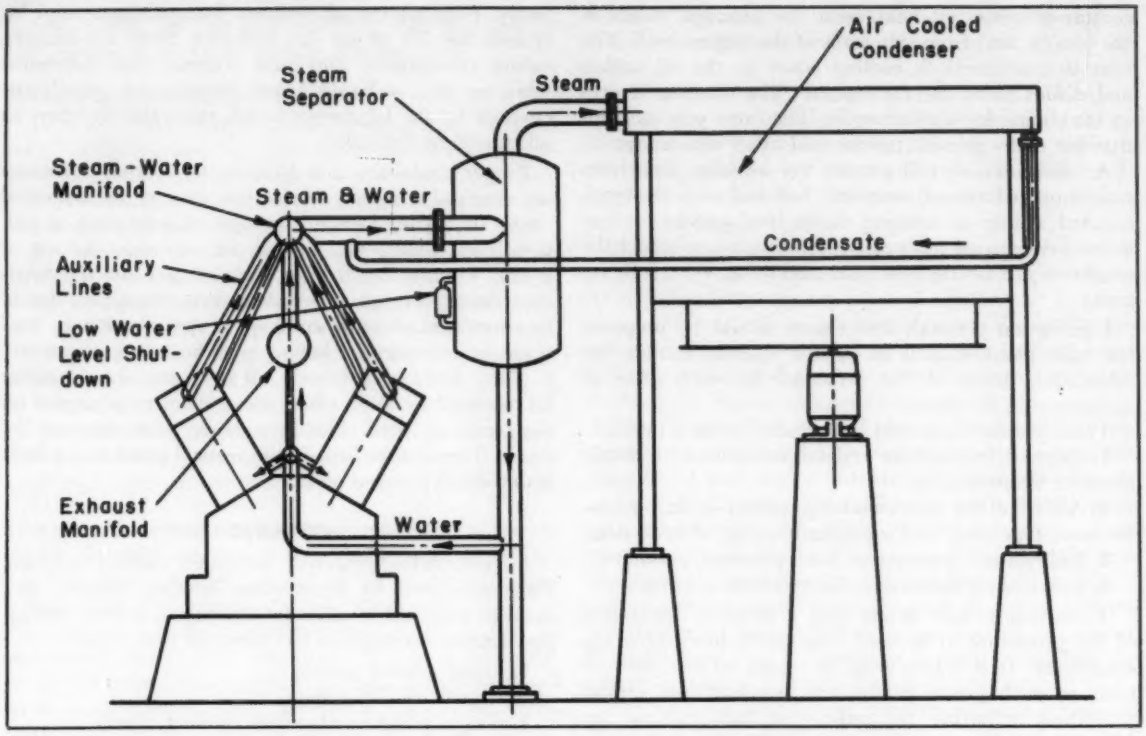


FIGURE 19—Scheme for vapor phase cooling unit with thermal circulation.

trol the velocity. As the engine is loaded or unloaded, this valve will close or open to maintain a constant outlet temperature of 170° F.

In many installations the inlet water temperature is governed by the temperature of the oil from the oil cooler to the engine; this same stream of cooling is usually used for oil cooling also. An example would be oil to an engine at a desired temperature of 170° F. and water inlet to the engine of 160° F.

Vapor phase cooling has a different pattern of operation; it is dependent upon thermal cycling for its operation. As water is heated, the hot water becomes lighter and will rise and be replaced with cooler water at the bottom. The vapor phase cooling system has a steam-water separator with the top elevated higher than the top of the engine. From the top of the separator a large line goes to a steam condenser; from the steam condenser a smaller line returns the condensate to the steam outlet from the engine. This condenser is a fintube type forced draft exchanger. Engines have special design features for this cooling.

Conventionally cooled engines have spiral webs of baffles in the cooling jackets to direct the water around in a spiral up the cylinder. Vapor phase cooled engines have these baffles drilled with large holes at numerous places around the cylinder to direct the water straight up the cylinder. This arrangement will not allow steam to become trapped under or between the baffle and cause extreme hot spots. Another requirement of vapor phase cooling is special gasket material on water connections, due to the increased temperature.

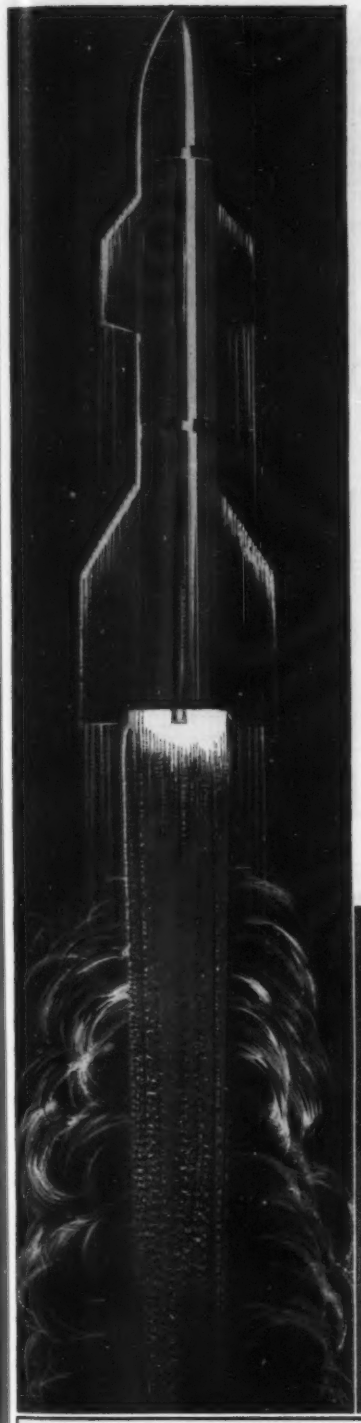
Let's trace the flow of vapor phase cooling (see Figure 19). As the engine is warmed and the load is increased, the water becomes hot, or actually boils within the engine cooling jackets. The water and steam will travel up through the engine jackets and on to the steam-water separator. Hot water is returned directly to the engine to replace water leaving the jackets; steam progresses from the separator to the condenser coolers, is condensed and returned to the hot water and steam from the engine.

Thus, an advantage of this type cooling is the elimination of the usual water pump. Natural circulation is sufficient for all flow purposes.

Heat is dissipated from the system by condensing the steam to water. This system is a completely closed system designed to operate under a low pressure. Pressures may vary from 1 to 5 psig, but water temperatures will vary greatly with increased system pressures. At 1 psi pressure the water will enter the engine at about 214 to 216° F. with the outlet water at 215 to 218° F., or about 1 to 2 degrees temperature rise across the engine jackets. If this system is increased to 5 psig pressure, the water inlet will be 230° F. with about the same temperature rise across the jackets (1 to 2 degrees). An operating pressure of 1 psig appears to be the most satisfactory.

Oil cooling for vapor phase cooled engines is accomplished with fintube type coolers mounted in the same air stream as the steam condenser. The oil cooler should be equipped with controls to maintain the desired temperature of the oil returning to the engine.

TO BE CONTINUED



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Recently the U.S. Navy and the Callery Chemical Company jointly dedicated their new HiCal plant in Muskogee, Oklahoma—America's first large-scale facility for the production of boron-based high-energy fuel. This new exotic fuel will power missiles, super aircraft, and possibly even man's first steps into space.

A large assortment of Ingersoll-Rand process compressors and pumps at Muskogee are working around the clock to maintain a continuous production schedule. One of the major processing units is the gas plant which produces hydrogen, carbon dioxide and nitrogen. Here a new-design Ingersoll-Rand ESH two-stage compressor handles carbon dioxide at 305 psig discharge, and another two-stage I-R unit compresses nitrogen to 500 psig. Two three-stage TVH's compress the hydrogen to 310 psig.

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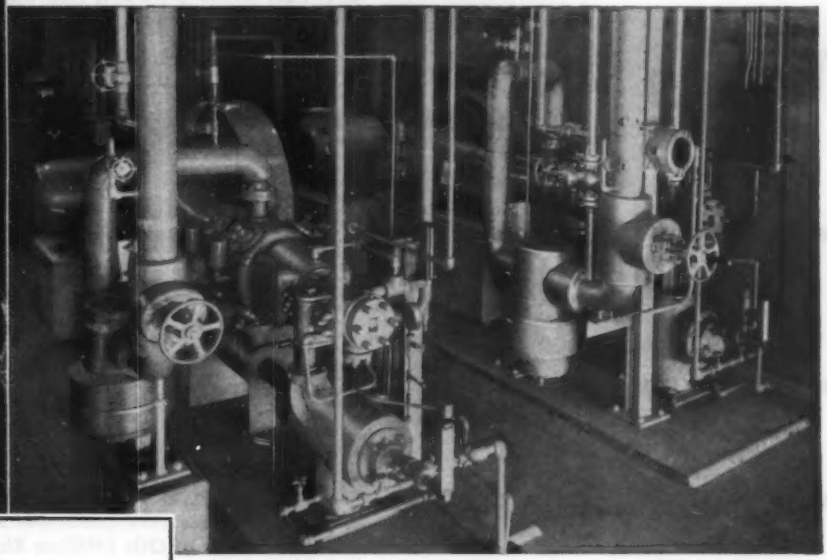

Ingersoll-Rand two-stage compressors at the new HiCal plant. At left, an ES nitrogen compressor; at right, compressing carbon dioxide, is an ESH unit of revolutionary new design.

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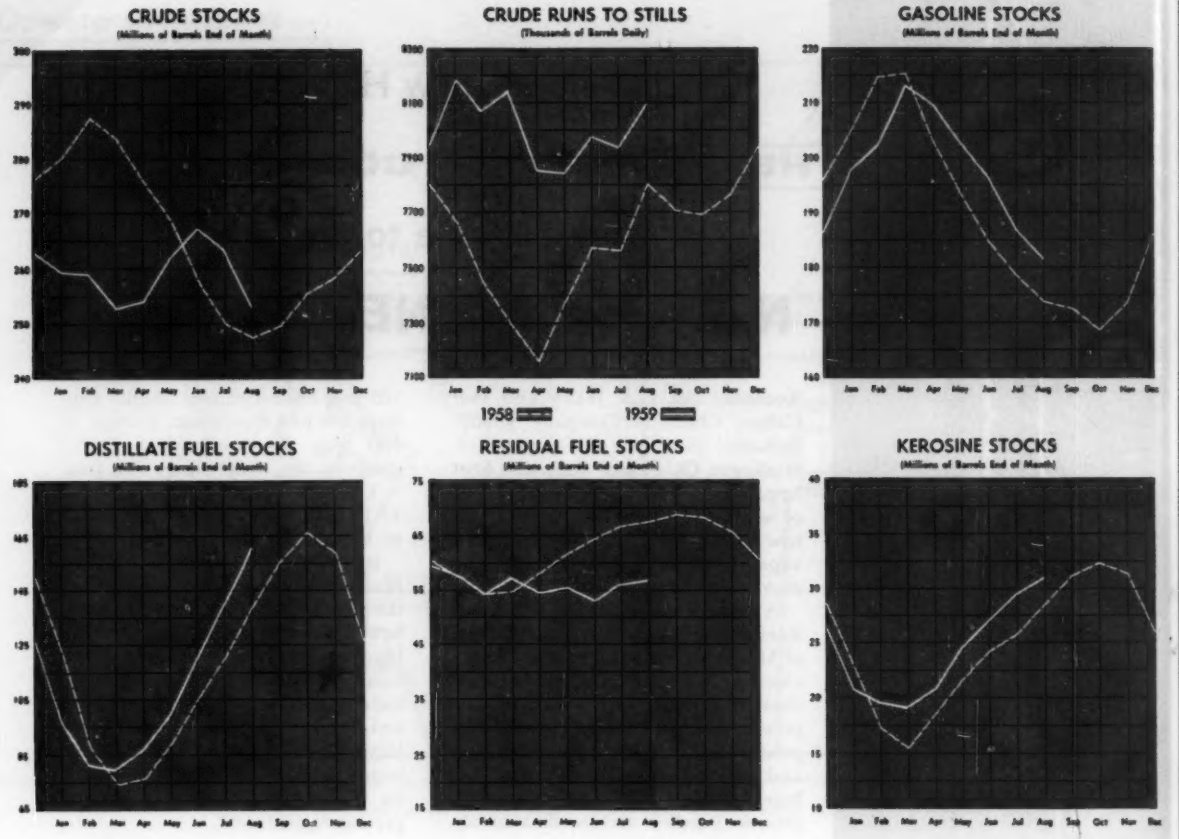


Taking Stock

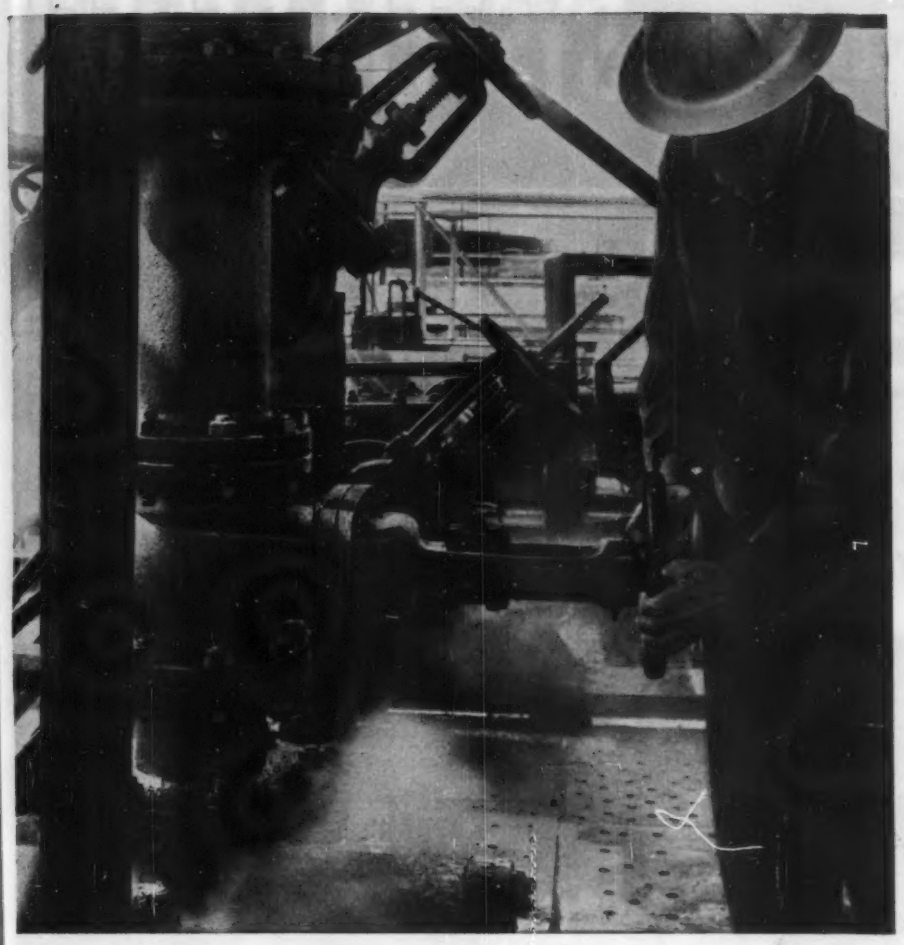
- Crude stocks continue to drop
- Runs to stills up sharply
- All other stocks following seasonal trends

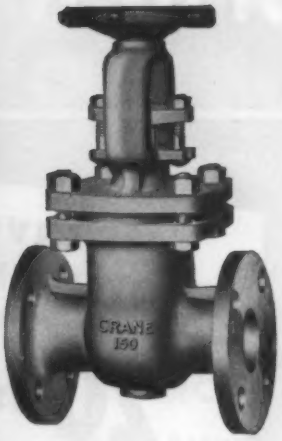
U.S. Petroleum Demand and Supply (Thous. Bbls. Daily)

ITEM	August 1959	August 1958	% Diff.	July 1959	January-August 1959	January-August 1958	% Diff.
DEMAND							
All Oils, Total Demand	9,078	8,696	+ 4.4	8,703	9,632	9,133	+ 5.5
Domestic Demand	8,823	8,392	+ 5.1	8,453	9,333	8,857	+ 5.4
Export Demand	255	304	—19.2	250	252	276	— 8.7
Gasoline, Total Demand	4,333	4,273	+ 1.4	4,436	4,122	3,948	+ 4.4
Distillate, Total Demand	1,125	1,091	+ 3.1	1,098	1,785	1,753	+ 1.8
Kerosine, Total Demand	215	172	+25.0	191	285	292	— 2.4
Residual, Total Demand	1,265	1,332	— 5.0	1,221	1,627	1,477	+10.2
Other Oils, Total Demand	2,140	1,828	+17.1	1,757	1,813	1,663	+ 9.0
CHANGE IN STOCKS							
All Oil, Change in Stocks	+145	+599	.....	+319	+170	—187	.....
NEW SUPPLY							
Total New Supply	9,223	9,295	— 0.8	9,022	9,756	8,946	+ 9.1
Domestic Production, Total	7,685	7,731	— 0.6	7,701	7,971	7,318	+ 8.9
Crude Oil	6,810	6,939	— 1.9	6,836	7,099	6,538	+ 8.6
Natural Gas Liquids	875	792	+10.5	865	872	780	+11.8
Imports, Total	1,538	1,563	— 1.6	1,321	1,784	1,628	+ 9.6
Refined Products	561	600	— 6.5	460	835	694	+20.3
Crude Oil, Total	977	963	+ 1.5	861	949	934	+ 1.6
Crude, East Coast	680	771	—11.8	624	731	762	— 4.1
CRUDE RUNS							
Crude Runs to Stills	8,106	7,824	+ 3.6	7,935	8,044	7,508	+ 7.1
Domestic Crude	7,118	6,814	+ 4.5	6,909	7,095	6,580	+ 7.8
Foreign Crude	988	1,010	— 2.2	1,026	949	928	+ 2.3

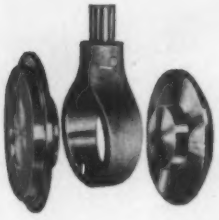
U.S. Stocks of Oils (Million Bbls. at End of Month)

KIND OF OIL	TOTAL IN U.S. August 1959	TOTAL IN U.S. August 1958	TOTAL IN U.S. % Diff.	TOTAL IN U.S. July 1959	EAST OF CALIFORNIA August 1959	EAST OF CALIFORNIA August 1958	EAST OF CALIFORNIA % Diff.	EAST OF CALIFORNIA July 1959
All Oils	824.4	794.5	+ 3.8	819.9	.....	.....	.....	.....
Crude Oil	252.9	244.8	+ 3.3	263.7	217.7	202.9	+ 7.3	227.7
Gasoline	182.1	177.4	+ 2.6	186.2	155.5	153.8	+ 1.1	159.3
Distillate Fuel Oil	161.6	139.9	+15.5	139.8	146.5	125.1	+17.1	125.4
Kerosine	31.2	28.7	+ 8.7	29.3	30.8	28.3	+ 8.8	28.9
Residual Fuel	57.0	67.2	—15.2	55.8	30.4	34.3	—11.4	29.0
Other Oils	139.6	126.5	+ 2.3	145.1	.....	.....	.....	.....





"Craneloy 20"—No. 20045 gate valve. ½" to 12"; 150 psi at 500 F; 230 psi at 100 F.



Crane split-wedge disc design. Free-to-rotate discs employ special guides to prevent rubbing against seat during operation.

"Craneloy 20" valves—performance-proved on toughest corrosive fluids

The "Craneloy 20" gate pictured above controls highly corrosive, hot sulphuric acid sludge at a large Western refinery. While other valves in this service had to be replaced every 3 to 6 months, this Crane valve lasted a full 14 months before requiring minor repairs.

All parts in contact with the flow are "Craneloy 20"—a high-nickel, high-chromium stainless alloy—poured in Crane's own foundries.

Crane alloy valves (either "Craneloy 20" or Type 316 stainless) give you an extra measure of value. Unique design of the split-wedge disc provides *uniform* pressure all around the seating surface . . . eliminates need for high seating forces. Free-to-rotate discs minimize seating wear and prevent galling.

For details of other features and applications of Crane alloy valves, see your Crane Representative.

Get full facts on "Craneloy 20" and other Crane quality alloy valves. Ask your Crane Representative for Circular AD-2080 or write to the address given below.

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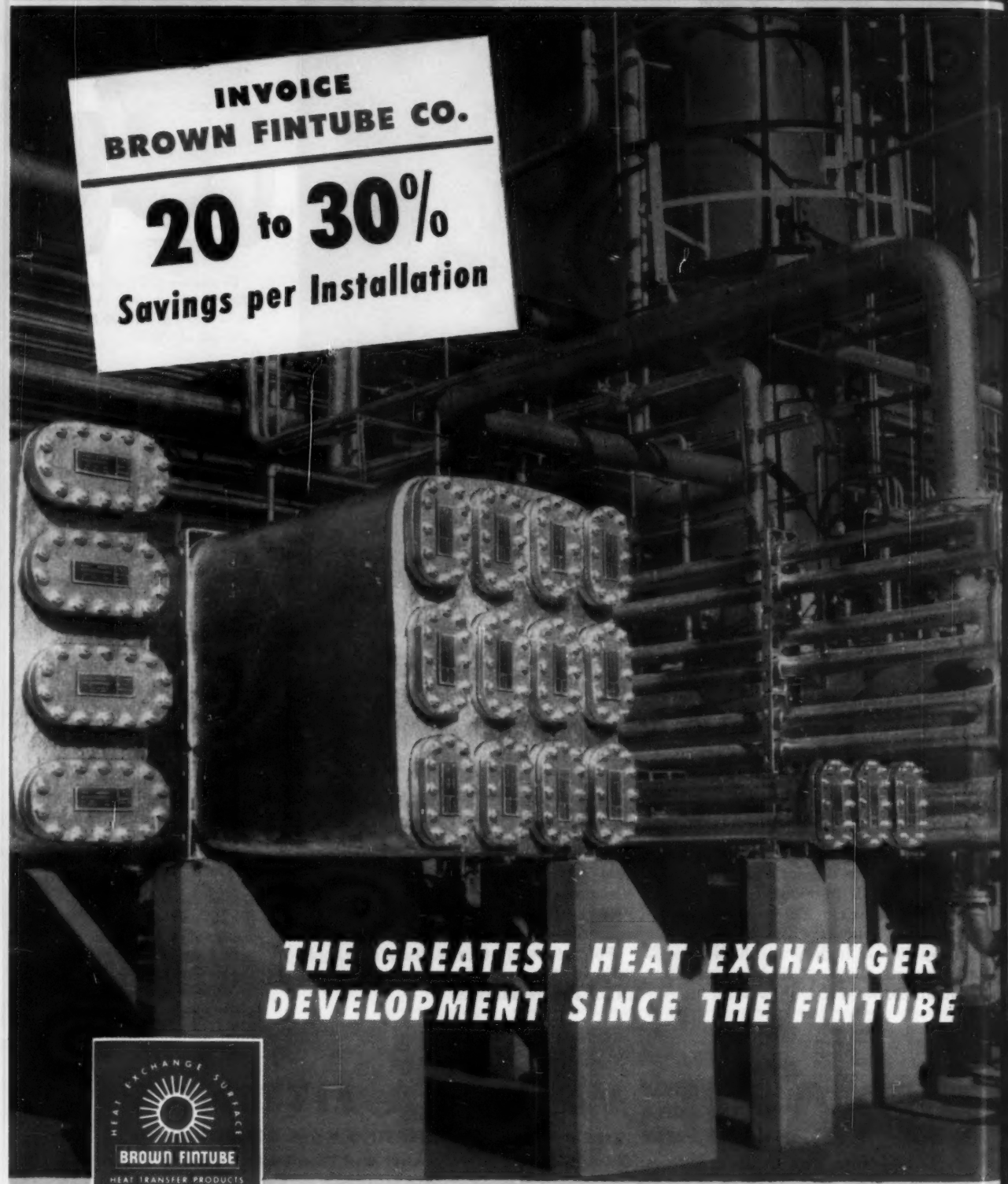

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You save because obsolescence is completely eliminated in the Brown system. **You use the same basic unit for all services,** regardless of duty, process or capacity changes.

DOWNTIME NEVER A FACTOR

Since all Brown modular units are identical, you can take one parallel stream off line, clean or service it and put it back **while the other sections continue to carry their capacity.** Furthermore, whenever any emergency arises, any stock Brown unit you have can be immediately pressed into service.

TREMENDOUS PARTS REDUCTION

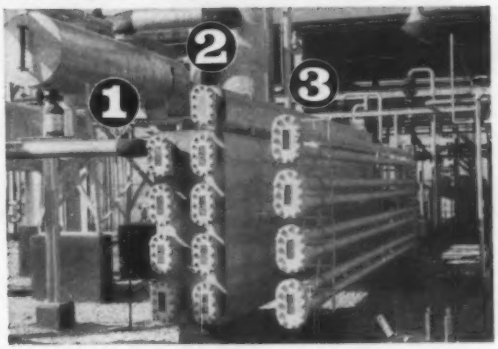
Many processes require seven basic types of shell and tube heat exchangers with over 784 different parts. Standardized Brown Fintube modular units for the identical applications **need less than 10 different parts:**

MAINTENANCE COSTS AT NEW LOWS

Brown units have a specially designed easy-to-open, easy-to-close head end assembly and rear end cover plate. That means with an ordinary pneumatic wrench, two men can open a section and substitute a clean hairpin **in less than ten minutes.** Furthermore, the plant standardizing on Brown equipment **has only one basic type unit to service!**

THESE ADVANTAGES, AVAILABLE ONLY WITH BROWN MODULAR UNITS, MEAN OPERATIONAL SAVINGS FOR YOU MORE IMPORTANT THAN INITIAL COST. SEND COUPON FOR FULL DETAILS.

How Flexibility in the BROWN MODULAR System Assures Greatly Increased Operating Economy



The Brown system consists of identical, low-cost modular heat exchanger units **that meet all duties,** as compared with the costly conventional method of individually designing and specifying a shell and tube heat exchanger for each duty. In the photograph above you can see **three different duties met by the same Brown units:** When a duty changes in a Brown equipped plant, an existing bank of sections can be altered to meet the new need by adding a few sections or removing a few sections, or rearranging the manifolding on short notice.

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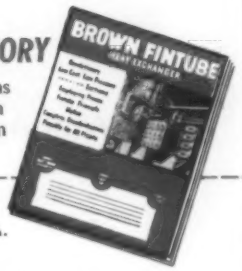

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Valuable Reading Ahead

Here's a quick run-down on what's presented in this month's non-technical sections. These departments will keep you right up-to-date with what's new and different in this rapidly changing oil industry.

Another "Boxscore"

Once again this month PETROLEUM REFINER presents its quarterly compilation of oil, gas and petrochemical processing plant construction projects from all over the world. Keep pace with construction trends by reading "Construction Boxscore"—the most complete and up-to-date guide to building in the industry. To see for yourself . . .

Keep going to Page 200

People Are Going Places

As the industry progresses, new jobs are opened and old jobs are filled by new men. You may know many of those who have been promoted, transferred or changed jobs recently. Take a look at "Men in Industry" to see what's happening to the men you know and those you would like to know. Simply . . .

Keep going to Page 264

Who's Building

The answer to this question is ready and waiting for you in this month's section of "Who's Building." There are dozens of construction items presented in capsule form so that you can get the maximum information in a minimum amount of time. There is also a lead story that will be of special interest. For comprehensive construction news . . .

Keep going to Page 190

What's Happening

"What's Happening In the Industry" is an accurate presentation of the items that made the news last month. The clear and concise manner in which events are reported is useful to busy industry men who don't have time to wade through unimportant details to reach the meat of the subject. And, at the end of this section, you'll find "Changing Times," a list of rapid-fire news flashes that provide the final touch to keep you informed. To read "What's Happening" . . .

Keep going to Page 246

As Management Sees It . . .

This month the lead article in the "As Management Sees It . . . " Department asks you what would you do if you were called upon suddenly to give an impromptu speech. Would you "er" and "ah" and thoroughly embarrass yourself and your audience? Not if you know and use the formula presented in this article. There are also some valuable pointers on how to go about giving two more special types of speeches. You're going to want to clip this article and save it for a long time to come, so to learn about "Three Hard Speeches to Make" . . .

Keep going to Page 225

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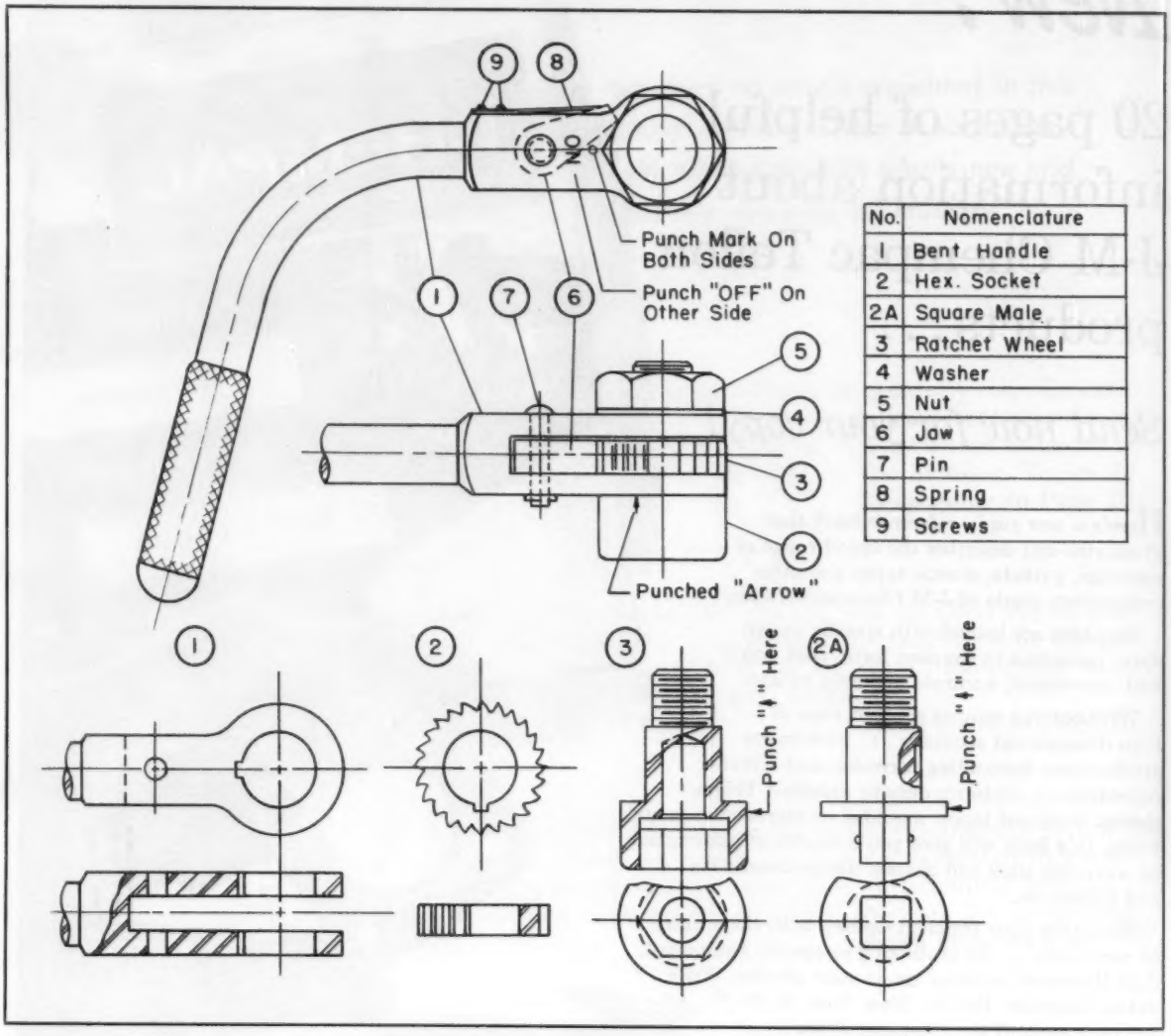


No.	Nomenclature
1	Bent Handle
2	Hex. Socket
2A	Square Male
3	Ratchet Wheel
4	Washer
5	Nut
6	Jaw
7	Pin
8	Spring
9	Screws

Bolt Wrench Makes Tight Work Easier

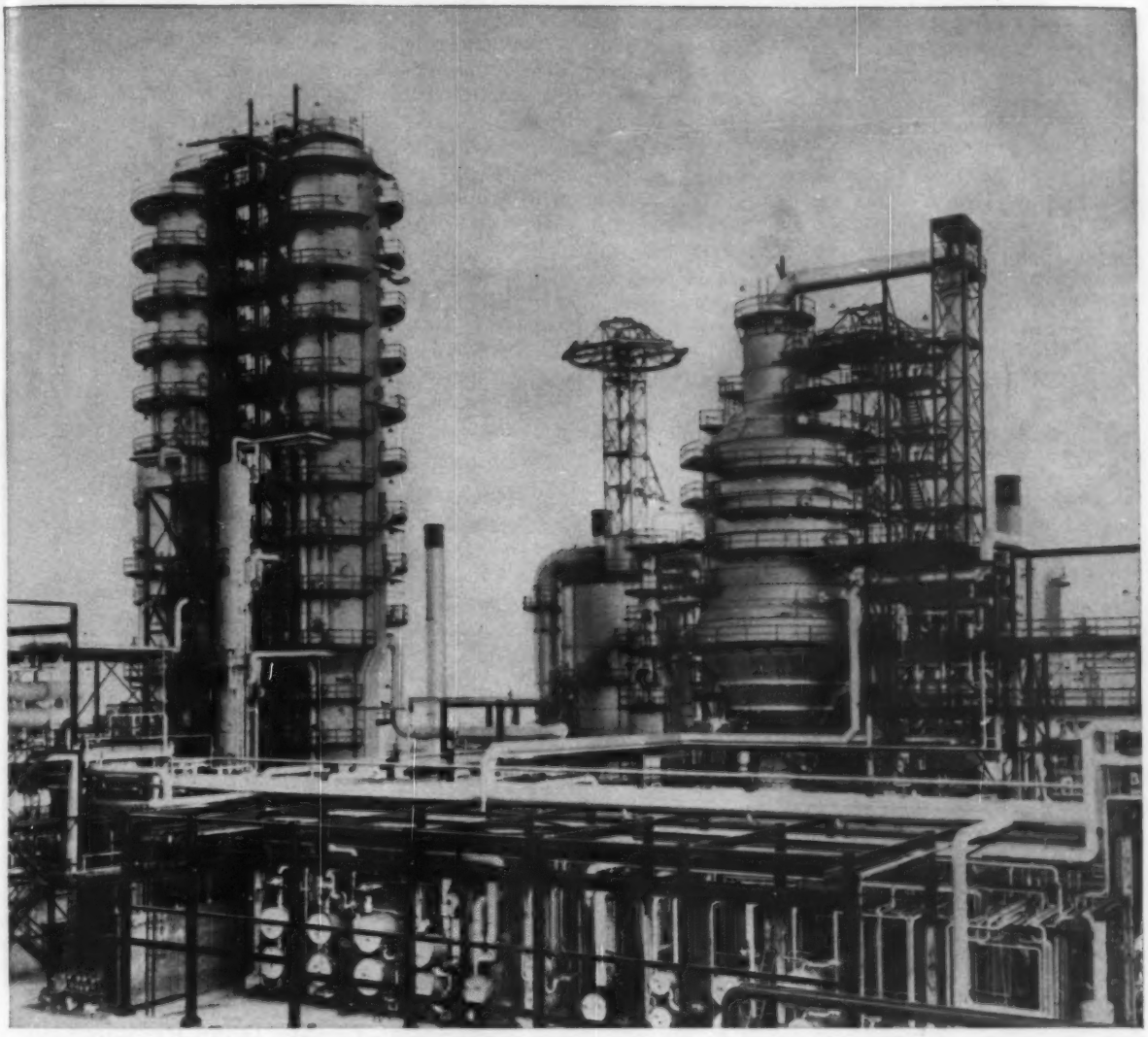
It's easy to make this pipe-flange bolt wrench, which combines bent handle principle and ratchet

Everyone who has ever worked on closely paralled pipe lines knows the difficulty of screwing and unscrewing flange bolts. The problem is further complicated by the fact that there are no special wrenches designed for this type of work except those with a bent handle construction pattern.

The problem was solved in a machine shop by designing a wrench combining the bent handle principle and the ratchet. The new tool consists of three major parts: the bent handle, the ratchet and jaw and a hex socket or square.

A ratchet wheel with 24 teeth makes it possible to work with a 15 degree movement of the handle. This solves the problem of limited space.

The ratchet allows power to be delivered in one direction. However, the direction may be reversed if desired. This is done by removing the nut



For economical protection from acid condensates, Monel Hortonclad is used in 13 ft diameter vapor top of vacuum column (right) and in upper portions of two 174 ft atmospheric crude columns (left), at the Marcus Hook Refinery of Sinclair Refining Company.

The bigger the tower top, the more it pays to clad it with Monel

The greater the tower top's inside area, the greater the savings by building with Monel* nickel-copper alloy clad materials.

Monel alloy cladding on steel gives lasting resistance to common tower top corrosive condensates. It also resists thermal shock, thermally induced stresses. Monel alloy clad steel is readily formed, welded without special equipment . . . post-weld heat treatment is not required.

In the Marcus Hook Refinery of Sinclair Refining Company (portion shown above), Monel Hortonclad** protects the upper portion of the two 174 ft atmospheric towers at left . . . and the vapor top of the vacuum tower at right. In all three, the use of clad material provides a substantial saving in costs.

Monel Hortonclad is manufactured and fabricated by the Chicago Bridge and Iron Company. For more information on practical Monel alloy uses in your refinery, write:

*Inco trademark
**T. M. of Chicago Bridge & Iron Company

HUNTINGTON ALLOY PRODUCTS DIVISION
The International Nickel Company, Inc.
67 Wall Street New York 5, N. Y.

MONEL®

For more data on advertised products, use Readers' Service Cards, last page.

How To Do It . . .

(Item 5), aligning the punch mark on the handle fork (Item 1) and the punched arrow on the hex socket (Item 2) or on the square socket (Item 2A). This lines up the socket key and the groove in the handle fork so that the threaded socket or square (Item 2 and 2A) may be removed from the bored holes in the fork.

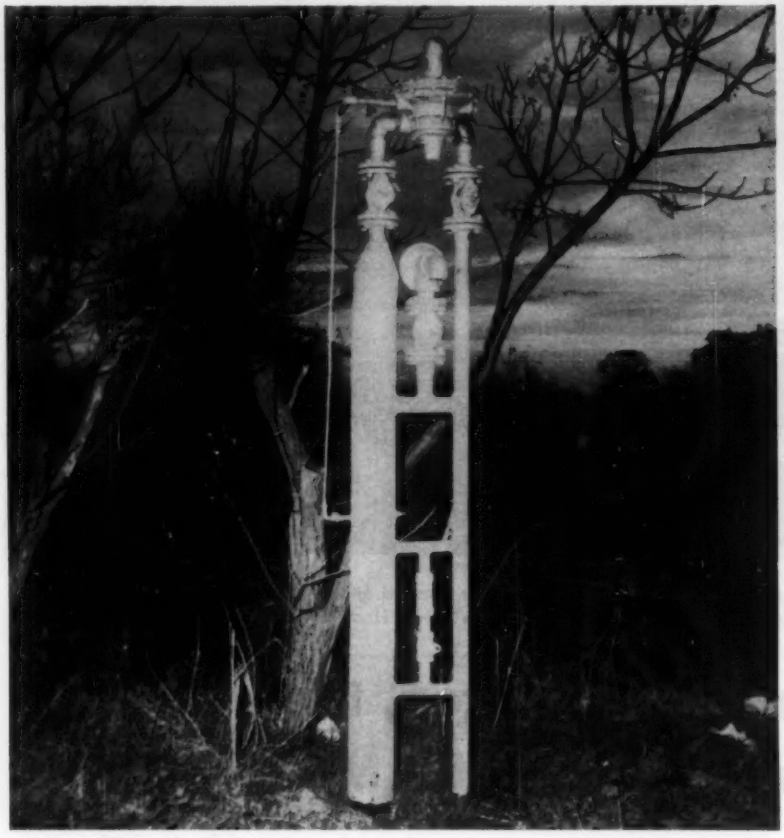
To reverse the action of the wrench, simply insert the socket or square in the opposite side of the fork, put on the washer (Item 4) and the nut.

This latter arrangement is to remove a nut or to screw it "OFF." The punch marks on the handle "ON and OFF" always indicate the action that the wrench will perform on the nut.

The reversible feature of the wrench is very simple and the average mechanic can perform this operation in less than 10 seconds.

The wrench is very versatile and can be used as an independent tool for repetative jobs or may be used for several classes of jobs using sockets to meet the work requirements.

This idea was submitted by Chang Chi-An, Chinese Petroleum Corp., Kaohsiung, Taiwan (Formosa).



Vertical Pressure Reduction Saves Space

Where space is at a premium around a refinery, a pressure reducing station may be mounted on a vertical run as shown. By placing the regulator at the top of the assembly, it is kept dry and thus free from freezing because of entrained hydrates.

In the illustration, the gas is passing from right to left. A drip is placed at the bottom of the two-inch riser and the control line for the regulated downstream pressure is placed in the middle of the six-inch riser. At the bottom of the run, a bypass valve and union is placed so that they can be easily replaced if necessary. The relief valve is located next, going up the run, and is of course connected to the downstream side of the run, the upstream side being blanked off. The reducing regulator is placed at the top out of reach of molesters and is set on flanged gate valves so that it can easily be replaced should any trouble occur.

This idea was submitted by Harry Hess, Houston.

Grease Drum Reclaims Those Oil-Can Drippings

To keep the refinery power plant policed, take a small grease drum and cut holes in the sides to hold empty oil cans. Whenever a can has been emptied, it is placed into one of these holes and allowed to drain completely. Where premium grade oil is used, these drippings will amount to a sizable volume in a weeks time.

The container is mounted on a small platform with casters attached so that it can be easily moved around the shop or plant. Handles on the side make it easy to handle. A spigot on the bottom facilitates the removal of the salvaged lube oil.

YOUR IDEAS ARE VALUABLE!
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...or your profits... *mix imagination with Alcoa Aluminas*

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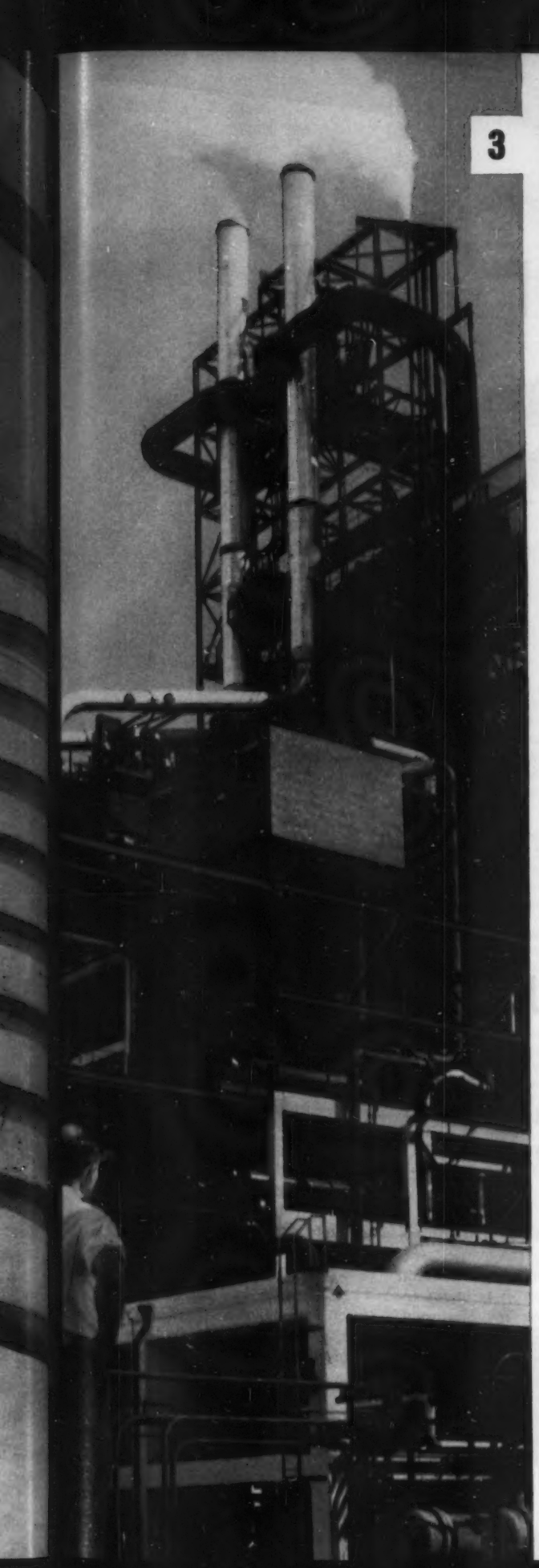

3 Stainless Steel wins three more battles with corrosion

1 High temperature sulfur corrosion from sour crude destroyed every metal tower in this plant. As the failures occurred, all towers were replaced with Stainless Steel lined equipment. Not one lining has failed since, and some of them have been in service continuously for eight years.

2 Two vacuum evaporators at this plant remove gas oils and asphalt from reduced crude at operating temperatures of 740° F. The evaporators were unlined at first, and inspection showed that they were failing rapidly from high temperature sulfur corrosion, coupled with severe erosion caused by the crude which entered the evaporators under pressure. The evaporators were promptly lined with Stainless Steel sheets, and, in five years of service, the sheets showed practically no wear. Plant engineers say they will be good for five to ten more years.

3 When they switched from sweet crude to sour crude in this "cat" cracker, the lower section of the fractionating tower corroded and had to be shut down for major repairs. The tower was repaired by installing Stainless Steel in all corroded areas. After three years of operation, the Stainless Steel was still in excellent condition.

When you consider all the materials that go into a refinery or petrochemical plant, very few will show such dramatic results as Stainless Steel. No other metal has such a desirable combination of corrosion resistance, surface density and smoothness, strength (even at high temperatures) and ease of fabrication. Build and repair with Stainless Steel. And for service-tested quality, specify USS Stainless Steel.

USS is a registered trademark

USS

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National Tube – Pittsburgh
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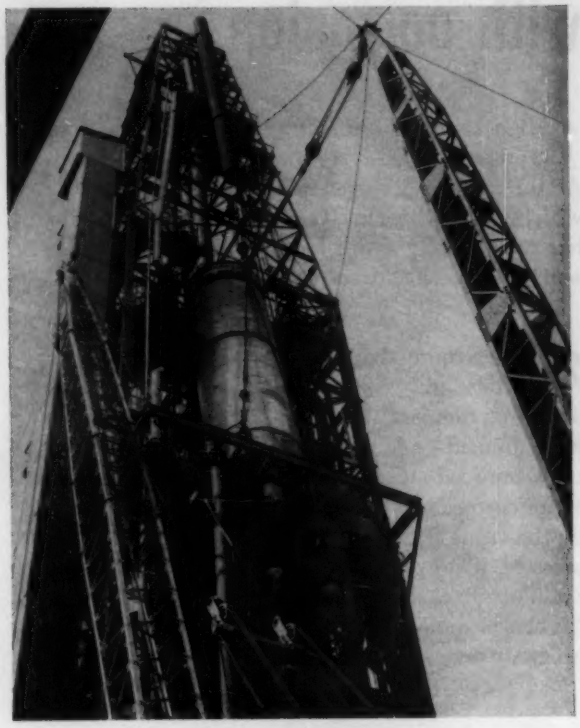
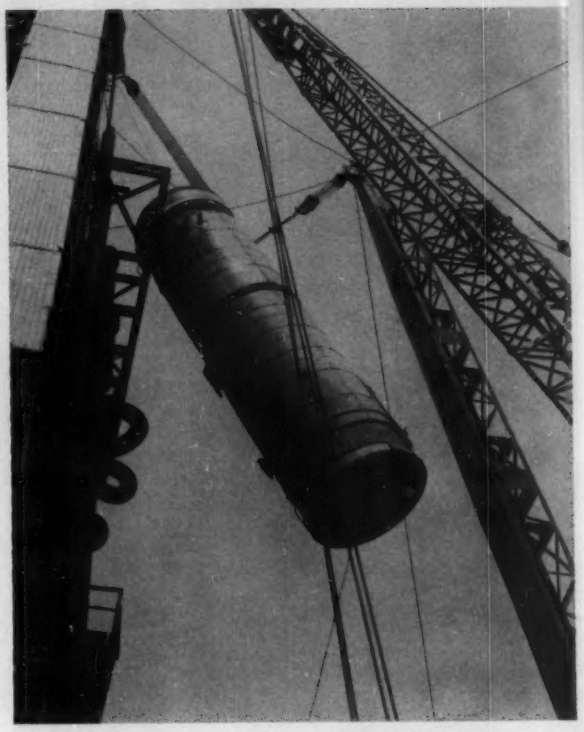
Tennessee Coal & Iron – Fairfield, Alabama
United States Steel Supply – Steel Service Centers
United States Steel Export Company

United States Steel

Who's Building...



Cables are secured . . .



. . . and down she comes.

Vessel Lowered in Unusual Operation

Delicate task was involved in lowering 65-ton reactor from cat cracker to ground 100 feet below

A unique and difficult operation was performed recently when riggers of The Fluor Corp. eased a 65-ton reactor vessel from the middle of a 270-foot high catalytic cracker and lowered the vessel 100 feet to the ground. The operation took place at Signal Oil and Gas Co.'s refinery at Signal Hill, Calif. Before it merged into Signal, the former Hancock Oil Co. owned the refinery.

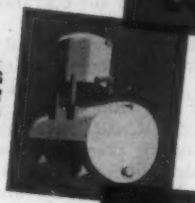
Since Signal plans to move and expand the unit at its refinery operations elsewhere, the vessel was purchased by Fluor for installation in a new cat cracker it is engineering and constructing for Shamrock Oil & Gas Corp., Sunray, Texas. Fluor needed the reactor immediately, so it moved the massive vessel out of its enclosing framework of structural steel beams and bracing.

This delicate task consisted of cutting a number of steel members to remove the vessel, and leaving the structure intact until later dismantlement. A long section of kiln flue-gas stack was also removed so the vessel could be coaxed out of the structure with two hoisting lines working through two sets of load blocks.

One set of load blocks operated between the vessel and the structure. The other set was put into play between the vessel and a 150-foot gin pole. When the hoist lines were brought into action—pulling in or letting out a bit of line here and there—the reactor swung free from the "cracker" and hung suspended in a canted position. The vessel had to tilt so that it could be properly lowered

TURBINE-GENERATORS

STEAM AND GAS TURBINES (mechanical drive, power recovery)



DEAERATING FEEDWATER HEATERS

STEAM JET EJECTORS

TURBOCHARGERS (for 2-cycle and 4-cycle engines)

CROCKER-WHEELER MOTORS (1 hp to 300 hp)

LARGE MOTORS AND GENERATORS

TUBE CLEANERS AND EXPANDERS

STRAINERS AND FILTERS

CENTRIFUGAL COMPRESSORS

Progressive engineering and research at Elliott

have developed many specialized products for petroleum refineries

An outstanding example is power recovery equipment. For many years Elliott engineers have been perfecting methods of putting hot process gases to work. This experience has resulted in a new line of process gas turbine-compressors developed especially for application to fluid catalytic crackers. Utilizing energy from the hot waste gases, this equipment permits substantial saving in the power cost of compression.

Another recent Elliott development is a compact, low-flow, high-head centrifugal oxygen compressor. Specially designed aluminum oxide bearings are water lubricated, reducing explosion hazard and eliminating lube oil contamination.

Elliott's famous line of ribbed-frame Sealedpower motors, pioneered in the United States by our Crocker-Wheeler plant, are now available in enclosed and explosion-proof frames up to 300 hp.

Other Elliott accomplishments over the years include tube cleaners, introduced when pipe stills first appeared on the scene; steam jet ejectors for maintaining vacuum on stills; steam turbines for safe and efficient drives all around the refinery; centrifugal compressors; condensers, of all types and sizes; deaerating feedwater heaters; turbochargers for getting more power out of diesel and gas engines; a line of effective single, twin, and self-cleaning strainers; tube expanders and tube accessories. All of these have grown with the refinery industry, have served and are serving it well.

Sixty years of distinguished performance in the petroleum industry

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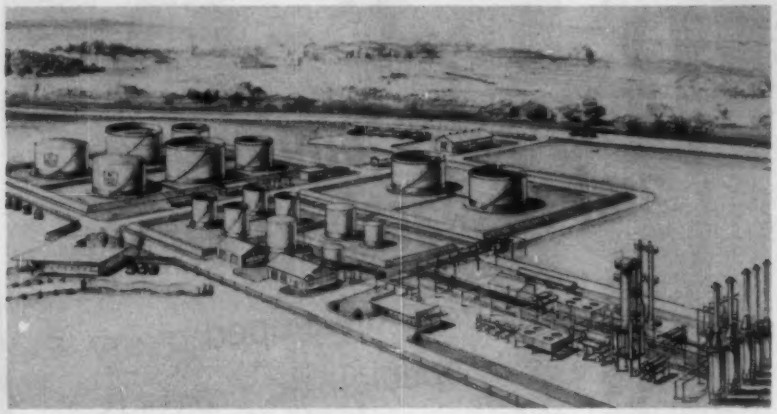
groundward between the pole and the structure.

The vessel was jockeyed between the two hoist lines for more than two hours before it reached the ground. It was then loaded onto a lowboy trailer and trucked to a vessel fabricator, where it is being modified with new internals, top head and outlet pipe required for the Shamrock job. When modifications are completed, the reactor will be shipped to Texas.



New $4-Million Gas Plant for Alberta

A refinery specifically designed to utilize liquids recovered from the processing of natural gas from Alberta's gas fields is being built by Canadian Oil Companies, Ltd.

The $4-million refinery will be located about 25 miles south of Red Deer, Alb., close to Canadian Oil's Innisfail oil field discovery.

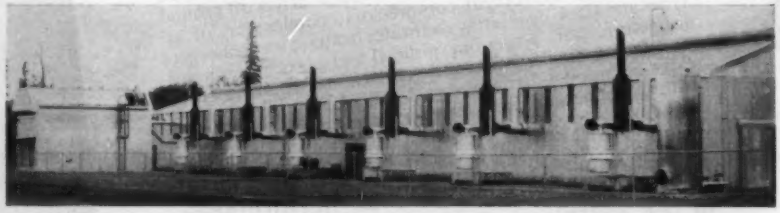
Construction began in September and the plant is scheduled to go on stream in the late fall of 1960. Canadian Bechtel, Ltd., has been awarded the contract for engineering and construction.

Design of the 30-million-gallon-per-year plant was made jointly by Canadian Oil Companies' Engineering Department and Canadian Bechtel. The new plant will be of advanced but simple design giving high gasoline yields with minimum production of bunker and byproducts, while keeping investment and operating costs to a minimum.

It will handle 4,000 bpd of condensate from natural gas processing plants in neighboring areas, and will process up to 2,000 bpd of crude oil as supplementary feedstock.

The plant will be built on a 70-acre site on the main highway connecting Calgary and Edmonton with an extra 200 acres held in reserve for future expansion. It will include facilities for crude fractionating, hydro-desulfurizing and platforming, besides the most modern equipment for gasoline blending, product handling, truck loading, and storage capacity of more than 300,000 barrels.

The refinery will include buildings to house offices, plant laboratory, administration departments, warehouses and garages, and fire control installations.



Gas Plant Said To Be Canada's Largest

What is claimed to be Canada's largest gas liquid extraction plant was recently placed in operation by Goliad Oil & Gas Co., Calgary, Alb. This $18-million installation will serve eight of the nine conservation units, or more than 250,000 acres of the Pembina Field in Alberta. The eight compressor plants collect up to 85 MMcf of gas daily from 290 tank batteries. They extract 196,000 gallons of liquid daily, including propane, isobutane, n-butane, and natural gasoline at a central fractionation plant. In addition, 65 MMcf of residue gas is supplied daily for utility use.

Shell Oil Co.'s Little Creek, Miss., natural gasoline plant is being expanded to permit additional producing wells in the field to be placed on gas lift. The expansion includes addition of two new compressors and extension of the gas gathering system to connect new producing wells.

Gas received at the plant from the wells is compressed and returned to the field for injection through the tubing into the wells. About 4 MMcf of gas is being used each day. The new compressors will provide an additional 7 MMcf of gas for lift operations. The plant also extracts daily some 10,000 gallons of natural gasoline and 4,000 gallons of propane from 5 MMcf of natural gas.

Located on a six-acre site just south of the Lincoln-Pike County line, the Little Creek installation is Shell's first gasoline plant in Mississippi. It is a refrigeration-type unit which at one point reduces the temperature of the gas to —20° F.

Standard Oil Co. of Calif. has completed construction at Richmond, Calif., of the first commercial Butamer unit for conversion of normal butane to isobutane, designed and licensed by Universal Oil Products Co. The unit is integrated with a new alkylation plant, with both sharing the same deisobutanizer column. High concentrations of isobutane in the effluent from the Butamer process amount to about 60 percent for each pass of normal butane. The product is a motor fuel blending component.

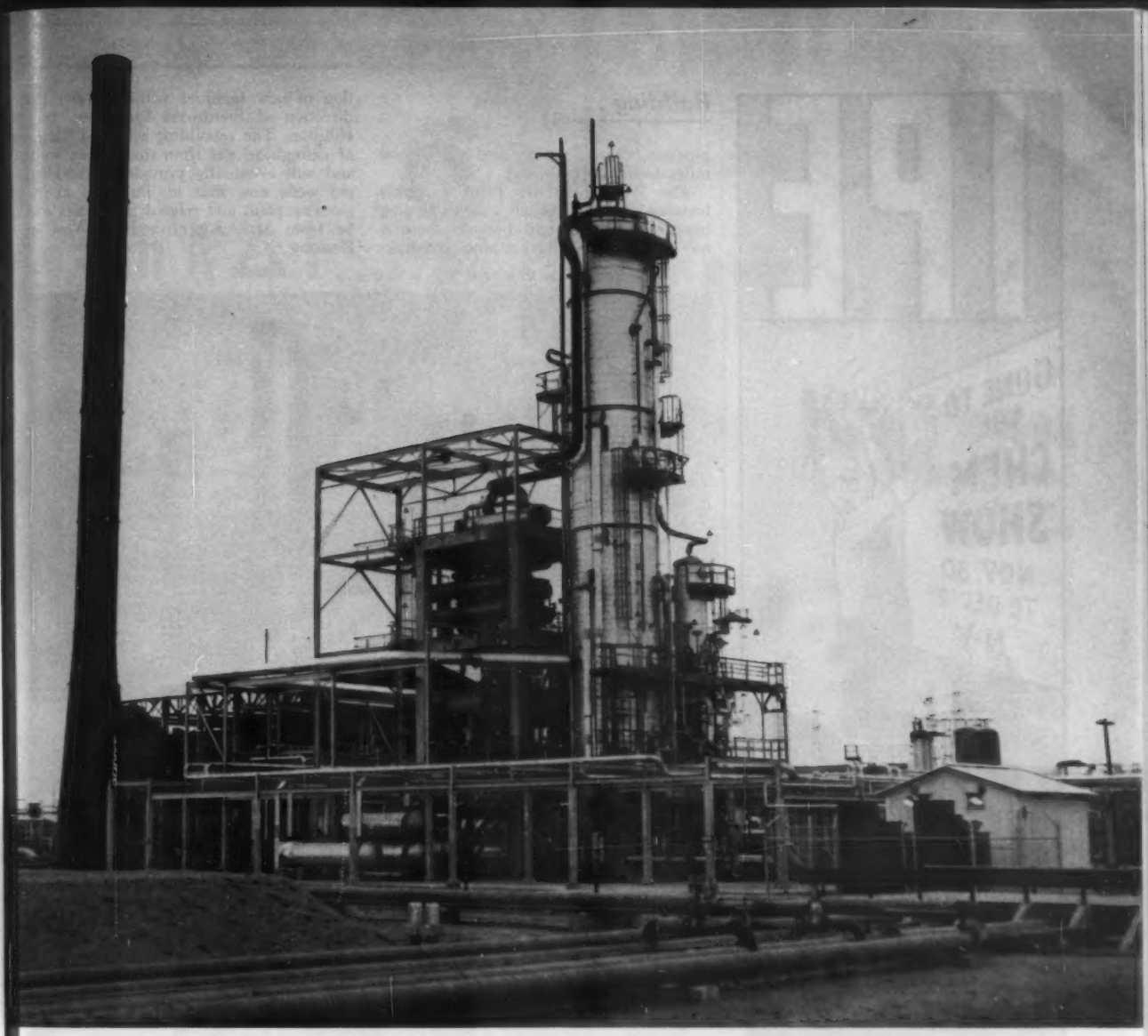
The Butamer unit is capable of handling 5,900 bpsd of reactor feed stock and producing 3,200 bpsd of net isobutane product. It takes its normal butane charge from Standard Oil Co. of Calif.'s new cat cracker, via the alkylation unit fractionation system, plus n-butane from other sources. The unit went on stream less than a year and a half after formal announcement of the Butamer process by UOP.

The Dow Chemical Co. will build polypropylene production facilities at Torrance, Calif., on a site adjacent to other Dow plastics production units. The facilities, said to be the first of their type for the Western United States, will cost several million dollars.

The plant, slated to go on stream in 1961, will specialize in production of thermoplastic raw materials for molding, coating, film, and foam applications.

The Spur Oil Co., Houston, has exercised an option to purchase the West gasoline plant in the Hull Field, Liberty County, Texas, and further reported plans for a $1 million plant rebuilding program and pipeline system. Initial capacity of the new plant and pipeline will be 10 MMcf of gas a day, but this will be increased to 20 MMcf when the demand arises.

Processing units will remove propane and butane from natural gas and compressor stations will move the plant's tailgate gas to market outlets, via a new



HESS TRADING AND TRANSPORT UNIT COMPLETED IN SEVEN MONTHS FROM START OF ENGINEERING

A crude distillation unit and a complete utility system—the basis of a new refinery—has been designed, engineered and constructed by Lummus for Hess Trading and Transport, Inc., Port Reading, New Jersey, in exactly seven months.

Engineering was begun on April 1, 1958 and on November 1, 1958 the refinery was ready for operation. Twenty-one days after crude was charged, the performance tests for the unit were successfully completed and the unit has been operating at capacity on various charge stocks.

Lummus designed the unit to assure a general-purpose refinery which is capable of processing various types of crude.

In addition to the crude distillation unit, the off-site facilities include: a complete electrical system, a water cooling and circulation system, steam generation equipment, waste water system, TEL blending and dyeing system, instrument air, plant air, fuel gas, and fuel oil systems. All were designed by Lummus to allow for future expansion.

For design, engineering and construction of refineries anywhere in the world—Lummus' over fifty years of world-wide experience on over 800 plants for the process industries is at your disposal.

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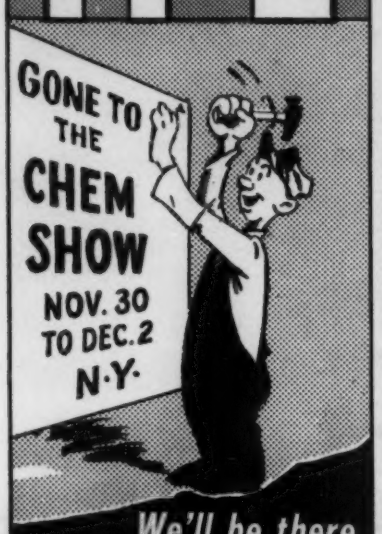

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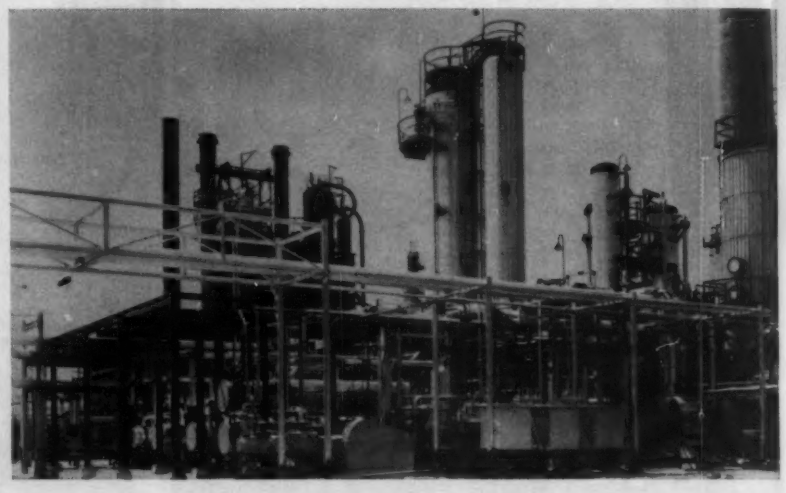
DAYTON 1, OHIO

SERVING THE CHEMICAL AND ALLIED INDUSTRIES FOR OVER A QUARTER CENTURY

Building . . .

pipeline. Closest market outlet is several miles from the plant.

The West gasoline plant currently handles 3-5 MMcf of gas a day, stripping liquids but flaring gas because there is no pipeline. Engineering and construction of new facilities will be under the direction of Southwest Industries, Inc., Houston. The rebuilding will end flaring of casinghead gas from many area wells and will eventually provide markets for gas wells now shut in. Purchase of the gasoline plant and related properties will be from Mrs. Katrina Low West of Houston.



Lion Completes New Deasphalting Plant

A new deasphalting plant for Lion Oil Division, Monsanto Chemical Co., El Dorado, Ark., is on stream. Constructed by Badger Manufacturing Co., the 5,260-bpd unit will use propane and butane as solvents to convert low-grade fuel oil feeds into various grades of salable asphalt.

Instrumentation and control in the new installation is completely electronic. To install controls, panel boards from an operating crude unit control house were removed from the building without interfering with the operation of the crude unit.

A good proportion of the plant's production is slated for use in the interstate highway construction program. By-products will be retained for in-plant use in the manufacture of other petroleum derivatives.

S.p.A. Celene, Sicily, jointly owned by Union Carbide Co. and Societa Edison of Milan, plans to double its polyethylene capacity to 60 million pounds per year, and expand petrochemical activities to include ethanol, butanol, 2-ethyl-hexanol and ethanolamines. The additional polyethylene facilities will be at Priolo, near Syracuse.

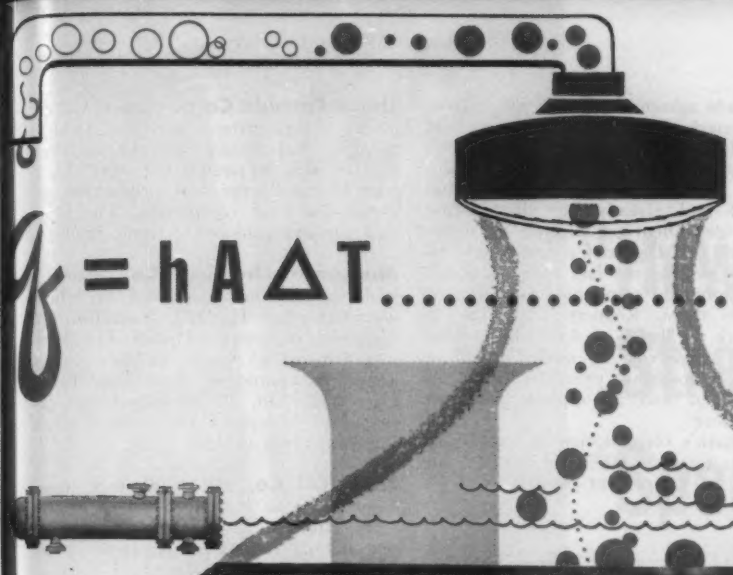
Czechoslovakia has completed its new 900,000-ton-per-year refinery, constructed by Techno-export at Homs. The plant will produce 180,000 tons of gasoline, 150,000 tons of kerosine, 200,000 tons of gas oil, 60,000 tons of diesel oil and 280,000 tons of fuel oil. Design allows for a 25 percent increase in capacity.

Irish Refining Co. has completed its new 40,000-bpd refinery at Whitegate, Ireland. The project was begun in September 1957. Products include premium and regular gasoline, kerosine-type jet fuel, propane, butane, and lubricating oils. Construction was handled by the Esso Petroleum group, which will act in an advisory capacity in the future.

E. I. duPont de Nemours & Co. has started work on its planned $50-million-pound-per-year caprolactam plant at Beaumont, Texas, and expects the plant to be completed by late 1960. The new facility will produce cyclohexalamine in addition to caprolactam, and both products are slated for outside sales.

Eastern Petroleum Corp. has received approval from the Thailand government to build a 25,000-bpd, $33-million refinery in Thailand. The plant, which would be designed to allow for expansion to 35,000 bpd, would be turned over to the government after 10 years of operation.

Tidewater Oil Co. plans a multi-million-dollar petroleum refinery and storage terminals project in Denmark. The refinery will have an initial crude capacity of 20,000 bpd and built-in provision for increasing this capacity to 40,000 bpd or more. The plant is planned for Kalundborg, an industrial seaport on the Island of Zealand, 62 miles west of



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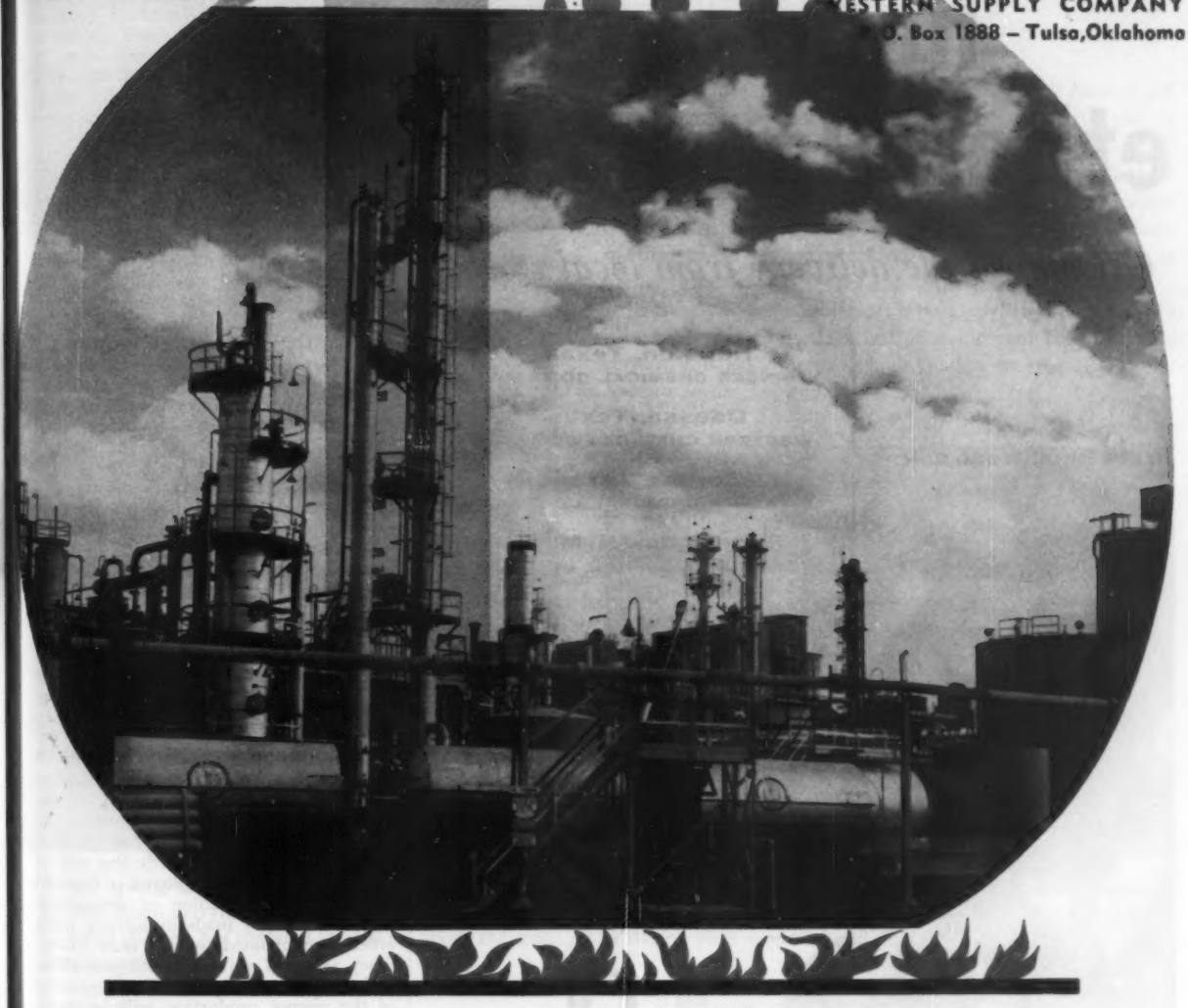

Anti-freeze is but one of many products whose origin can be traced to the South Works of Wyandotte Chemicals Corporation, Wyandotte, Michigan. In the Propylene Oxide Plant of the South Works, shown above, Western Heat Exchangers render a significant and vital service to Wyandotte's continuing growth in organic oxide chemicals.

Precise engineering, practical design and close attention to detail characterize all Western heat exchangers — tailored to the process requirements of the nation's leaders in petrochemicals.

A Western representative stands ready to help with your heat transfer requirements.

Building . . .

Copenhagen. Terminal storage and distribution facilities will be built at strategic marketing points throughout the country.

Bids for construction of the project are being sought from both American and European firms. The project is planned for completion in 1961, some 18 months after start of construction.

Tidewater has established a Danish corporation, Dansk Veedol, as the operating company, which will manufacture major petroleum products at Kalundborg, with emphasis on fuels.

Denmark is presently importing all of its petroleum products. Under a recent trade agreement, Russia may export to Denmark about 3.5 million barrels of fuel oil over the next two years. Russia now supplies fuel oil to Sweden, can deliver petroleum products to Finland by rail and already has that nation largely dependent on Russian oil fields. This will be Denmark's first crude oil refinery, despite the fact that six major international oil companies market their products there. Refinery capacity in Denmark is listed at 4,250 bpd. This capacity, however, is made up of a 3,500-bpd naphtha pyrolysis plant in Copenhagen and an asphalt plant in Kalundborg.

Denmark's consumption of petroleum products totaled 85,000 bpd in 1958, an increase of 12 percent over 1957.

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Union Carbide Corp. plans to up capacity of high-pressure polyethylene at its Seadrift and Texas City, Texas, plant by 170 million pounds per year. Facilities to handle the new production are slated for 1961 completion. The plans call for expansion of existing facilities.

Monsanto Chemical Co. plans to build a petrochemical plant at Silverwater (Sydney Harbor) Australia. The company is associated with Petroleum and Chemical Corp. in the project, under the name of Australian Petro-Chemicals, Ltd. To be owned and operated by Monsanto, the plant is slated for completion in 1961.

Shell Oil Co. will unite with three other firms to build a refinery in Karachi, Pakistan, to be jointly owned with that nation. Others participating in the $33-million plant are Standard Vacuum Oil Co., Burmah Oil Co., and California Texas Oil Co. Pakistan will own 40 percent of the project, and the U.S. companies will own the remainder. Completion of the new unit is expected to take about 36 months.

Maruzen Oil Co. has established a $6.9-million petrochemical affiliate, Maruzen Petrochemical Co., to be headquartered at Osaka, Japan. The new firm is building a plant at Matsuyama to produce 550-600 tons of methyl ethyl ketone and secondary butyl alcohol. Currently under construction, the $7.2-million plant will produce 2,000 tons per year of terephthalic and orthophthalic acid and 5,000 tons per year of isophthalic acid, when completed in April 1960. It will be constructed by Scientific Design Co.

Knapsack-Griesheim reports that it is considering the use of petroleum coke for production of acetylene in Germany. The firm is studying the possibility of reviving the old method of making acetylene from calcium carbide. Briquettes would be made from petroleum coke and lime—then passed through an electric furnace to make calcium carbide. Acetylene is then created by reaction of the carbide with water, and the intense heat produced is recovered.

Koninklijke Zwavelzuurfabrieken v/h Ketjen N. V., Amsterdam, plans to build a plant for production of synthetic phenol. Anhydrous sodium sulfite will be available as a by-product. Production is to begin towards the end of next year. Part of the phenol is destined for company production of derivatives. Some are already made by Ketjen, while others are planned for the near future. They are used in making lacquer resins and synthetic detergents. The remainder of the phenol production will be available for the Dutch market. Plant capacity can be easily adapted to an increasing demand.

Texas Butadiene & Chemical Corp. and Hess Terminal Corp., have signed a contract covering erection and operation by Hess, at its Houston

"How Jessop Stretches Specialty Steels"

Robert Timko, Metallurgist

"At Jessop, tensile testing of specialty steels is carried out with far more than ordinary precision. It pays. It's one of the reasons our repeat business is so high.

"Based on a series of photographs, this drawing shows a specimen of type 304 annealed stainless steel bar at the climax of a tensile strength test. Moving apart, the heads of the tensile testing machine stretched the bar until it finally ruptured at 5500 psi above the spec."

In this Jessop metallurgical laboratory, top metallurgists using all types of modern testing equipment help us make certain you get *consistent* high quality in specialty steels. *Specify Jessop . . . and then relax.*

VMA 6768

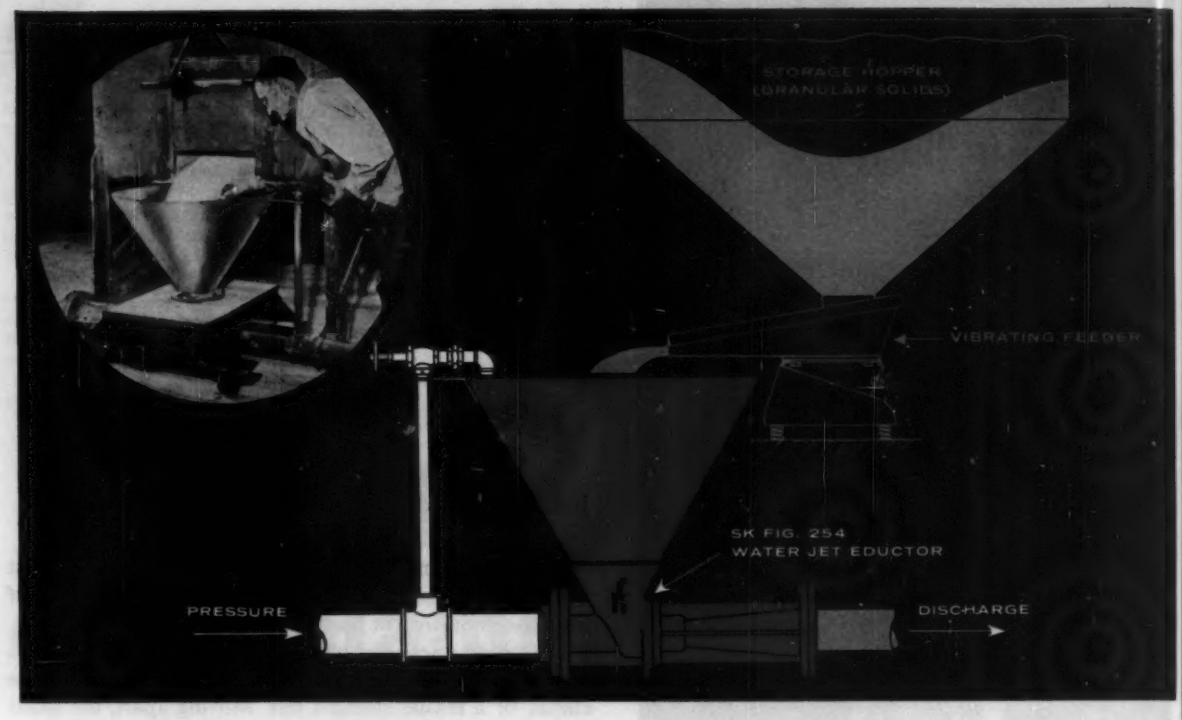
Tensile testing machine in the Jessop metallurgical lab. Stretch, strain and then bang! The specimen of type 304 annealed stainless bar ruptured at 5500 psi above the spec. Tensile strength okay!

In the Jessop metallurgical lab, this tensile testing machine is one of many types of tools used to make certain you get *exactly* what you want in specialty steels.

Jessop Steel International Corporation
Steel Warehousing Corporation, Chicago
Green River Steel Corporation
Jessop Steel of Canada, Ltd.

JESSOP
STEEL COMPANY
Washington, Pennsylvania

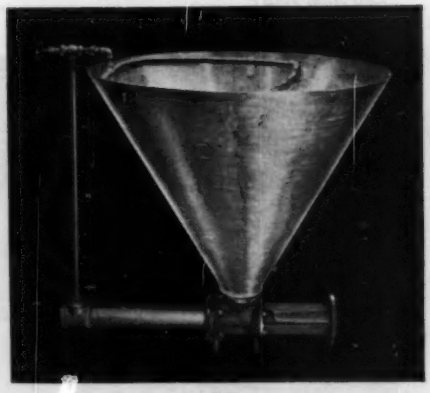
Stainless, alloy, cast-to-shape, clad and forging steels, ground flat stock and other specialty steels



MIX SOLIDS WITH LIQUID, CONVEY SLURRIES

with this SK "Hopper Type" Water Jet Eductor

SK Fig. 254 Hopper Type Water Jet Eductor



SK's Hopper Type Eductor, shown above and at left, will mix solids with liquid and convey slurries conveniently and at low cost. See box below for types of granular solids currently being handled.

An inexpensive unit, this light-weight eductor is easy to install, simple in construction with no moving parts, requires little maintenance, and provides efficient service over long periods. In operation, pressure water, issuing through the nozzle, entrains granular solids from the hopper and discharges through discharge piping. Agitating jets keep material moving down into the eductor.

Used in the petroleum industry, in chemical processing and food processing plants, the hopper eductor has proved to be extremely satisfactory in handling the materials (bulk densities noted) listed below and others.

For full details on Hopper Type Eductors including sizes, capacities, ratios, water consumption, materials of construction, write to SK for Bulletin 2M.

SK HOPPER EDUCTORS ARE BEING USED CURRENTLY TO HANDLE THE FOLLOWING MATERIALS *(Approx. Bulk Densities Indicated in Parentheses)*

Borax (50-55)	Fly Ash (35-40)	Sawdust, Dry (13)
Charcoal (18-28)	Rosin (67)	Soda Ash, Light (20-35)
Diatomaceous Earth (10-20)	Salt, Granulated (45-51)	Sodium Nitrate, Dry (80)
Lime, Pebble (56)	Salt, Rock (70-80)	Sulphur, Powdered (50-60)
Lime, Powdered (32-40)	Sand, Damp (75-85)	Wheat (48)
Mash (60-65)	Sand, Dry (90-100)	Zinc Oxide, Powder, Dry (10-35)

JET APPARATUS: Ask for Condensed Bulletin J-1.
ROTAMETERS & FLOW INDICATORS: Ask for Condensed Bulletin M-1.
VALVES: Ask for Condensed Bulletin V-1.
HEAT TRANSFER APPARATUS: Ask for Condensed Bulletin HT-1.
GEAR PUMPS: Ask for Bulletin G-1.

Schutte and Koerting
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MANUFACTURING ENGINEERS SINCE 1876
2257 State Road, Cornwells Heights, Bucks County, Pa.

Building . . .

Ship Channel terminal, of what is said to be the largest specially designed butadiene terminal ever constructed. It will be used by Texas Butadiene to store butadiene for domestic and overseas customers.

The terminal will consist of two 40,000-barrel ellipsoids, each having a capacity of 4,000 tons. Butadiene will be delivered by an 11-mile pipeline from TB&C's Channelview, Texas, plant. Before flowing to storage it will be cooled to 35° F.

Connecting pipelines will enable loading of ocean-going ships at a rate of more than 250 tons per hour. Tank trucks and cars also may be loaded. Construction of the facility is to be completed this month.

Mitsubishi Oil Co. is building a 40,000-bpd refinery in Japan. Tidewater Oil Co. owns 50 percent of the Japanese firm.

Getty Oil Co. plans an expansion of the 30,000-bpd refinery at Gaeta, Italy, which it purchased last year. Capacity will be upped to 52,000 bpd within two years, and the company is contemplating an expansion from wholesale to retail marketing.

British Petroleum Co. and Shell Oil Co. plan construction of a 28,000-bpd refinery at Mombasa, East Africa. The $36-million plant is slated for completion in 1963.

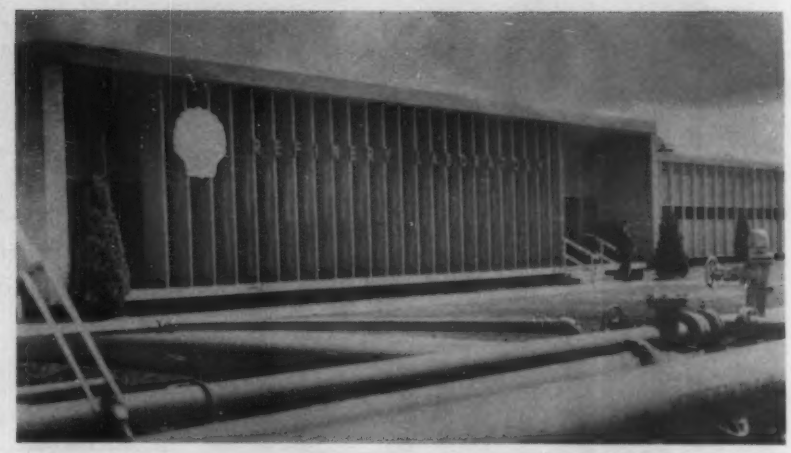
U.S.S.R. has reportedly refused a request for a larger loan to India for construction of a planned 50,000-bpd refinery at Barauni. The Indian government is said to feel that the Russian offer would provide only for a "second-class plant."

Midland Cooperatives, Inc., plans to build a 1,300-bpd alkylation unit at its Cushing, Okla., refinery. To be built by Procon, Inc., the unit is to be complete by April 1960.

Allied Chemical Corp.'s National Analine Division plans to increase its maleic anhydride capacity at Moundsville, W. Va., and Buffalo, N. Y. The expansion at both sites is to be completed by the end of this year.

True Oil Co. plans to build a natural gasoline extraction plant in the Coyote Creek area, Wood County, Wyo. National Tank Co. will construct the plant, which employs an oil adsorption refrigeration system, to process gas from several recent discoveries in Northeastern Wyoming.

Filoil Refining Co., a new Philippine firm in which Gulf Oil Co. owns a 25 percent interest, will build a 10,000-17,000-bpd refinery on the island of Luzon, Philippines. The new company is capitalized at $30 million.



Shell Oil Completes Norco Laboratory

Another step in modernizing general facilities at Shell Oil Co.'s Norco refinery was completed recently as a new refinery laboratory began operations. The one-story, air-conditioned structure now combines all laboratory functions under one roof.

Formerly, laboratory facilities had been located in several different buildings. In the new arrangement, more than 27,000 square feet of laboratories, offices and attendant areas are housed in one building. Covered platforms and storage areas occupy another 2,200 square feet, providing greater efficiency and minimum delay in handling the hundreds of samples collected daily from various operating units.

Facilities in the new building include laboratories for analytical, physical chemistry, spectroscopy, light oil, asphalt, gas, and motor oil. The building also houses a small experimental laboratory and pilot plant.

An aerial view of downtown Houston with models of Humble Oil & Refining Co.'s 44-story, $35-million home office building and garage superimposed on the blocks they will occupy, illustrates changes the buildings will make in the city's skyline. This picture looks north. The six-story garage is diagonally across from the building (lower left in picture). A tunnel will connect the two structures.

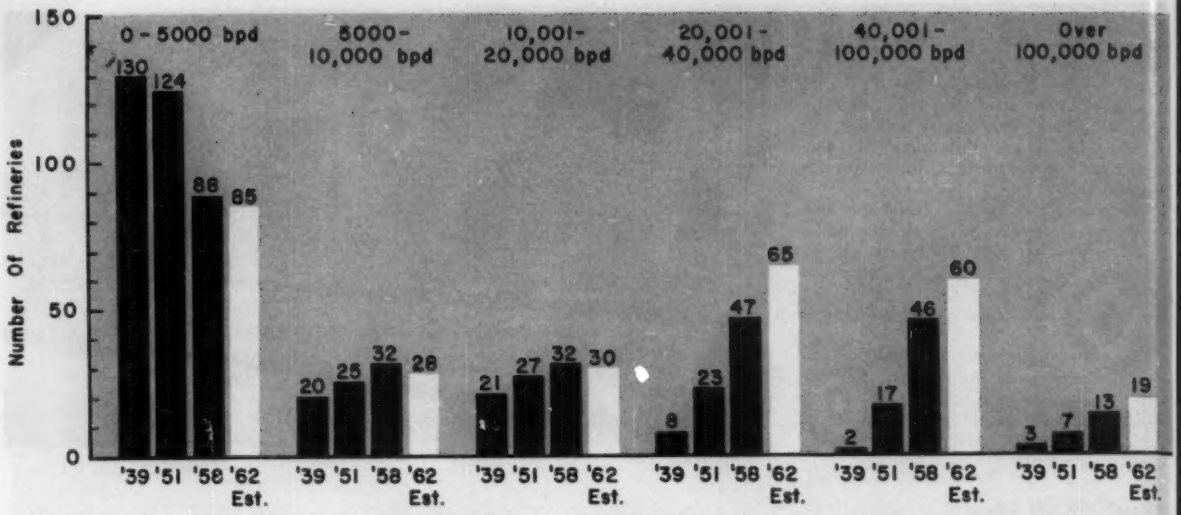


FIGURE 1—The number of refineries outside North America, USSR, China, and Eastern Europe are shifting to bigger sizes.

"Construction Boxscore" data reveal . . .

Bigger Refineries Are On the Way

European and domestic refineries are shifting to bigger sizes to get more economical operation

Charles H. Vervalin
PETROLEUM REFINER Staff

The trend toward building bigger refineries is continuing. Larger plants achieve the normal reduction in capital and operating cost per barrel of throughput which comes with increased size.

A survey[1] of refineries outside North America, USSR, China and Eastern Europe is shown in Figure 1. These data show a drop in the number of refineries having 5,000 bpd of capacity and less. At the same time there is a growth in the number of larger refineries being built. These data include an estimate of the number of plants which will be in operation in 1962.

The savings per unit of throughput which comes from bigger refineries is typical of most relations between size and unit costs. Costs for utilities, buildings, instrumentation and other such items does not increase in proportion to refinery size. Thus, capital cost can be shown[1] to decrease as in Figure 2.

Recent examples of large-size units for domestic refineries have appeared in past issues of PETROLEUM REFINER's Construction Boxscore. The latest is the completion of a 140,000-bpd pipe still for the Whiting Refinery, Standard Oil Co. (Indiana). This plant, which replaced nine smaller units,

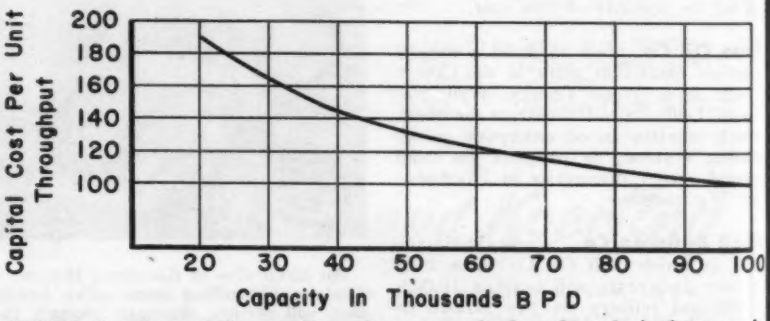


FIGURE 2—The capital cost of a refinery on unit throughput basis decreases by about the 0.6 power of the total capacity.

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Use Snap-Tite valved couplings and you'll never have to test lines to see if flow has stopped as you do with conventional valves.

The instant you disconnect the two halves of a Snap-Tite coupling, flow stops . . . and you know at a glance the line is closed. Reconnect and right away full flow begins again.

Snap-Tite couplings take up less space, prevent the possibility of leaking valves, save time and money in installation and maintenance. Ask your local Snap-Tite representative how much you can save by using Snap-Tite couplings.

SIZES: ¼" to 6" in aluminum, brass, steel and 303 and 316 stainless. Larger sizes and other metals on special order.

For more information, write for Snap-Tite Catalog #58. Ask for the name of your local Snap-Tite representative.

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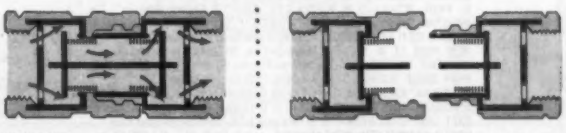

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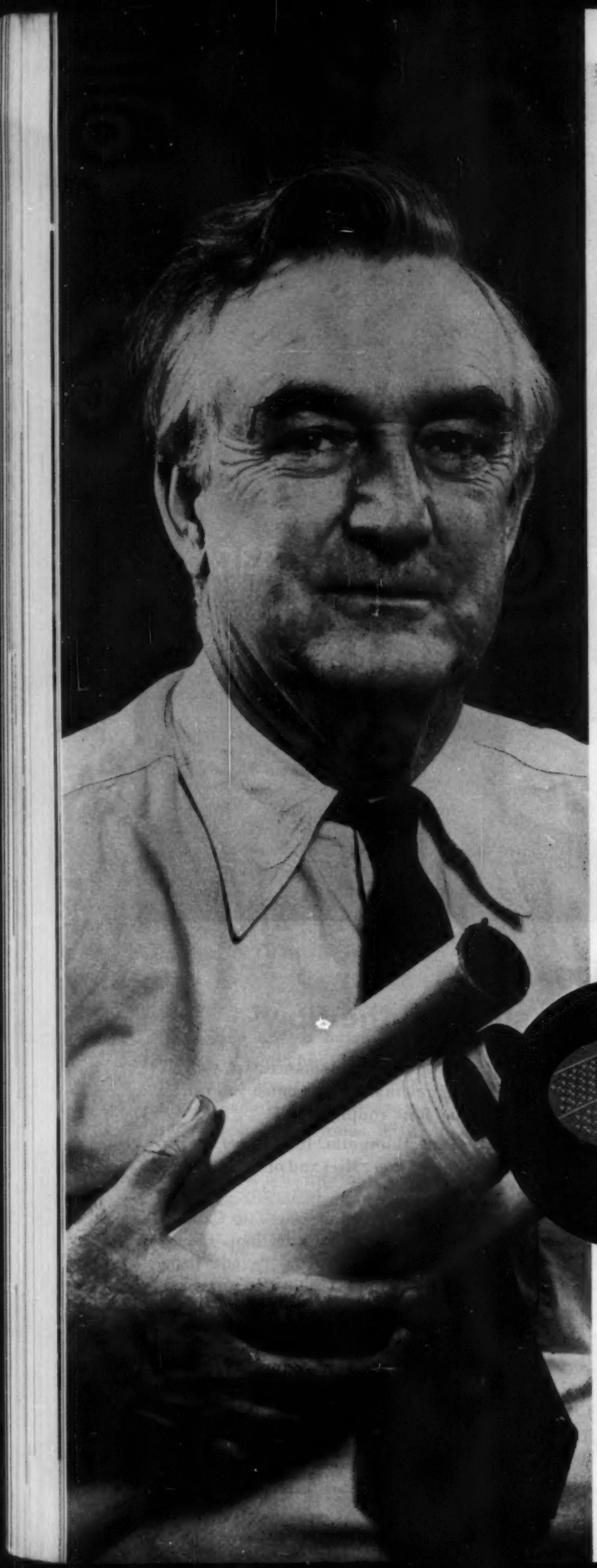

It's who's up front that counts

To the design engineer, "follow-the-leader" sometimes seems to be an industrial pastime.

Imitations always appear on the market to follow a leader – and, when they do, it is best to *choose the leader*, because:

If it is good enough to imitate, it must be superior!

When you specify fractionating trays for your next important installation, keep in mind that, "It's *who's up front* that counts"!

Then, count on Koch FLEXITRAYS for superior performance!

For extreme flexibility, higher capacities, and l-o-n-g-e-r cleaning cycles, specify the superior tray that others chose to copy – the Koch FLEXITRAY . . . *now in use by major companies in more than 1,000 non-captive installations!*

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European Fabrication Available

produces 64 percent of the refinery's 200,000-bpd of total throughput, and continues to operate at 90 percent capacity when the vacuum section is shut down.

Another unusually large unit recently put into operation is Socony Mobil's 100,000-bpd crude distillation unit.[2] This plant, which replaced seven smaller units, consists of an atmospheric crude distillation tower, two vacuum towers in series, a gasoline rerun tower and a stabilizer. An initial study revealed a larger crude unit would result in lower maintenance costs and higher productivity. However, it was found that higher productivity and lower maintenance of a basic replacement unit could not provide a sufficient payout. After four years of study, the following features were added to the basic replacement unit: added vacuum capacity, improved atmospheric fractionation, improved vacuum distillation, and gasoline rerun and stabilization.

Perhaps the most noticeable shift to big units in the U.S. came with the announcement of Tidewater's Delaware refinery. This 130,000-bpd refinery[3] contained a number of units which have the distinction of being the biggest in the world. Among these are the 102,000-bpd fluid catalytic cracking unit, the 42,000-bpd fluid coking unit, and a 45,000-bpd reforming unit. The plant also features an 88,000-bpd hydrodesulfurization section made up of five units.

Only time will tell what other companies will climb on the big-refinery bandwagon—but for the present the trend to higher capacity seems well established.

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[1] Frankel, P. H. and W. L. Newton, "Current Economic Trends in Location and Size of Refineries in Europe," presented before the Fifth World Petroleum Congress, New York, June 1959.
[2] Wharton G. W. and E. P. Hardin, PETROLEUM REFINER, Vol. 37, No. 10 (October, 1958), p 105.
[3] Anon, PETROLEUM REFINER, Vol. 36, No. 6 (June, 1957), p 148.

Construction Boxscore

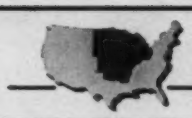
Oil, Gas and Petrochemical Processing Plants

East

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Allied Chemical & Dye	Buffalo, N.Y.	Polyethylene	.....	.....	Under Constr	.....	.....	.....	.....
American Cyanamid	Bridgeville, Pa.	Maleic Anhydride	20,000,000 lbs/yr	.....	Under Constr	Late 1959	S D	S D	S D
	Bound Brook, N.J.	Anthraquinone	4,000,000 lbs/yr	.....	Under Constr	.....	.....	.....	Foster Wheeler
		Naphthoquinone	1,000,000 lbs/yr	.....	Under Constr	.....	.....	.....	Foster Wheeler
		Phthalic Anhydride	7,000,000 lbs/yr	.....	Under Constr	.....	.....	.....	Foster Wheeler
Ashland O & R	Catlettsburg, Ky	Aliphatic Solvents	.....	.....	Complete	.....	.....	Procon	Procon
Atlantic Refining	Philadelphia	Revamp Visbreaker	20,000 bbls	$2,000,000	Complete	.....	.....	Atlantic	Atlantic
		*Crude Revamp	2,000 bbls	$2,180,000	Under Constr	Jan 1960	.....	Staff	.....
Carey Chemicals	Flemington, N.J.	*Polyvinyl Chloride, Polymers	.....	.....	Under Constr	1960	SD	SD	SD
Du Pont	Belle Works, W. Va.	Urea; Ammonia Methyl Methacrylate, Nylon Intermediates	.....	.....	Planned	1959	Texaco	.....	.....
	Florence, S.C.	*Polyester	.....	$20,000,000	Under Constr	1961	.....	.....	.....
	New Jersey	Hydrogen	.....	.....	Engineering	.....	.....	Chemico	Chemico
Esso Standard	Bayway, N.J.	Exp. Cat Cracker Light Ends	.....	.....	Under Constr	Early 1960	.....	.....	.....
Grace Chemical Div., W.R. Grace	Memphis	Exp. Urea	300 tons	.....	Under Constr	.....	.....	Foster Wheeler	.....
Gulf Oil	Near Charleston, S.C.	Refinery	.....	.....	Planning	.....	.....	.....	.....
	Philadelphia	*Oxo Alcohols	.....	.....	Under Constr	Dec 1960	Gulf Oil	Badger Mfg/Gulf	Badger Mfg/Gulf
Mississippi Chem.	Pascagoula, Miss	Urea	100 tons	.....	UnderConstr	1959	Inventor Ubde	Vulcan	Vulcan
	Yazoo City, Miss.	Urea	100 tons	.....	Complete	.....	Inventa, Ubde Vulcan	Vulcan	Vulcan
Montecatini	Neal, W. Va.	*Isotactic Polypropylene, Petrochemicals	11,000,000 lbs/yr	.....	Under Constr	.....	Staff	.....	.....
Pantesote	Passaic, N.J.	*Polyvinyl Chloride	.....	.....	Under Constr	1960	SD	SD	SD
Quaker State Oil Refining	Farmers Valley, Pa.	*Exp. Refinery	.....	$400,000	.....	.....	.....	.....	.....
Reichhold Chemicals	Elizabeth, N.J.	Maleic-Anhydride	20,000,000 lbs/yr	$4,000,000	Engineering	June 1960	Badger Mfg.	Badger Mfg.	Badger Mfg.
	Hampton, S.C.	Formaldehyde	30,000,000 lbs/yr	.....	Engineering	.....	.....	.....	.....
	Tuscaloosa	Formaldehyde	35,000,000 lbs/yr	.....	Planning	.....	Staff	Staff	Staff
Shell Oil	Little Creek, Miss.	Nat. Gas Liquids	5-MMcf	.....	Planning	.....	.....	.....	.....
Sinclair	Marcus Hook	Hydrodesulfuriser	20,000 bbls	.....	Under Constr	Late 1959	.....	Catalytic	Catalytic
Stauffer Chemical	Le Moyne, Ala.	*Methane Purification	.....	.....	Engineering	Spring 1960	.....	Treco	Treco
Sun Oil	Marcus Hook, Pa	Furnace Oil sulfuriser	15,000 bbls	$1,257,000	Under Constr	1959	.....	Staff	Staff
		Propylene Fractionating Facilities	60,000,000 lbs/yr	$1,965,000	Under Constr	1959	.....	Staff	Staff, others
		Exp & Modernise Grease Plant Facilities	.....	$450,000	Under Constr	1959	.....	Staff	Staff
		Exp. Wax Moulding and Packaging	.....	$637,000	Under Constr	1959	.....	Staff	Staff
		Automatic Tank Gauging System	.....	$428,000	Under Constr	Spring 1960	.....	Staff	Staff
		Product Control Center Combination Refinery Unit	.....	$150,000	Complete	Continuous Develop Work	.....	Staff	Staff
		Chassis Dynamometer Addition	.....	$352,000	Under Constr	1959	.....	Staff	Staff, others
		Automatic Crude Blending	.....	$230,000	Under Constr	1959	.....	Staff	Staff
SunOlin Chem.	North Claymont, Del.	Urea	200 tons	$8,000,000	Under Constr	Early 1960	.....	Kellogg/Staff	Kellogg
Tennessee Eastman	Kingsport, Tenn.	*High-Purty Nitrogen	900 Mcf	.....	Planning	Early 1960	.....	Girdler	Girdler
Union Carbide Chemicals	Institute, W. V.	Exp. Acrylonitrile	.....	.....	.....	.....	.....	.....	.....
		Epoxies	10,000,000 lbs/yr	.....	Under Constr	1959	.....	.....	.....

* First appearance in tabulation

Construction BOXSCORE Continued on page 204



Mid-Continent

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Aurora Gasoline	Detroit	Vacuum Distl.	18,000 bbls	.....	Under Constr	1959	.....	Treco	Treco
		Alkylation	2,000 bbls	.....	Complete	.....	.....	Treco	Treco
		*Naphtha Unifining	8,000 bbls	.....	Engineering	Late 1959	.....	Treco	Treco
Bay Refining	Bay City, Mich.	Crude Distl.	12,000 bbls	$900,000	Under Constr	1959	.....	Sweco	Sweco
		Alkylation	850 bbls	$850,000	Under Constr	1959	UOP	Sweco	Sweco
Callery Chemical	Muskogee, Okla.	Hydrogen	800,000 scf	.....	.....	.....	.....	.....	.....
		Carbon Dioxide	7,790 lbs hr	.....	.....	.....	.....	.....	.....
Century Refining	Garden City, Kan.	*Catalytic Cracking	3,000 bbls	.....	Under Constr	May 1960	Socony	Litwin	Litwin
		*Gas Concentration	.....	.....	Under Constr	May 1960	.....	Litwin	Litwin
		*C3-C4 HF Alkylation	800 bbls	.....	Under Constr	May 1960	Phillips	Litwin	Litwin
Cooperative Farm Chemicals	Lawrence, Kan.	Ammonia Urea	100 tons/30 tons	$5,400,000	Under Constr	August 1959	.....	Chemico	Chemico
		*Nitric Acid	130 tons	$1,250,000	Under Constr	Jan 1960	.....	Chemico	Chemico
Derby Refining	Wichita, Kan.	Alkylation	1,700 bbls	$1,500,000	Under Constr	1959	.....	Procon	Procon
		*Waste Disposal, Cooling Tower, LPG Storage	.....	$405,000	Complete	1959	.....	Litwin	Kaighn-Hughes-Litwin
		Waste Disposal, Cooling Tower, LPG Storage	.....	$405,000	Under Constr	1959	.....	Litwin	Kaighin Hughes/Litwin Staff
Dow Chemical	Bay City, Mich.	Petrochemical	.....	.....	Under Constr	1959	.....	Bechtel	Austin
		Polyethylene	.....	.....	Under Constr	1959	Zeigler	Bechtel	Bechtel
Du Pont	Circleville, Ohio	*Polyester	.....	.....	Under Constr	Early 1959	.....	.....	.....
DX Sunray	Duncan, Okla.	Cat Cracker Revamp	.....	$600,000	.....	.....	.....	.....	Treco
	Tulsa	*MEK, Solvent Dewaxing & Deoiling	5,835 bbls	$7,500,000	Under Constr	Sep 1960	Texaco	Foster Wheeler	Foster Wheeler
Goodyear Tire & Rubber	Point Pleasant, W. Va.	Polyester Resin	.....	$10,000,000	Complete	.....	.....	Catalytic	Catalytic
Grace Chemical Div. W. R. Grace	Memphis, Tenn.	Exp. Urea	300 tons	.....	Under Constr	1959	.....	Foster Wheeler	Process Contracting
Great Northern Oil	Pine Bend, Minn.	*Sulfuric Acid Alkiation	1,500-2,000 bbls	.....	Under Constr	Summer 1960	.....	Treco	Treco
Gulf Oil	Cleves, Ohio	*Distillate Treater	11,000 bbls	.....	Under Constr	1960	UOP	McKee	McKee
	Toledo, Ohio	*Distillate Treater	16,000 bbls	.....	Engineering	Dec 1959	Petrico	Staff/Kaighen & Hughes	Staff/Kaighen & Hughes
Kerr-McGee	Wynnewood, Okla	Exp Crude	25,000 bbls	.....	Under Constr	Jan 1960	.....	Litwin	Kaighin-Hughes-Litwin
		Vacuum Distl	10,625 bbls	.....	Under Constr	Jan 1960	.....	Litwin	Kaighin-Hughes-Litwin
		FCCU Revamp, TEL	.....	.....	Under Constr	Jan 1960	.....	Litwin	Kaighin-Hughes-Litwin
Lion Oil	El Dorado, Ark.	Unifiner—Platformer	5,000 bbls	.....	Engineering	.....	UOP	UOP/Procon	Procon
		Tetramer	340 bbls	.....	Under Constr	Oct 1959	UOP	Procon	Procon
		Exp Refinery	4,000 bbls	.....	Under Constr	Oct 1959	.....	.....	Lion
Monsanto Chemical	Monsanto, Ill.	Phenol Exp.	.....	.....	.....	.....	.....	.....	.....
	El Dorado, Ark.	Urea Distl.	.....	.....	Under Constr	.....	.....	Chemico	Chemico
Northwestern Ref.	St. Paul Park, Minn.	Cat Reformer	.....	.....	Planning	1959	.....	.....	.....
Phillips Pet.	Kansas City, Kan.	Alkylation	6,000 bbls	.....	Under Constr	1960	Phillips	Phillips	Procon
Reichhold Chemicals	Detroit	Formaldehyde	35,000,000 lbs/yr	.....	Planning	.....	Staff	Staff	Staff
	Kansas City, Kan.	Formaldehyde	35,000,000 lbs/yr	$500,000	.....	.....	.....	.....	.....
R & J Oil & Ref.	Princeton, Ind.	Unifiner	1,700 bbls.	.....	Planning	.....	.....	.....	.....
		Crude Distl.	5,000 bbls	.....	Under Constr	1959	.....	.....	.....
		Platformer	1,700 bbls	.....	Planning	.....	.....	.....	.....
Shell Oil	Wood River, Ill.	Exp. Lube Oil	4,000 bbls	$10,000,000	Complete	.....	.....	Lummus	Lummus
		*Catalytic Reformer & Offsite Facilities	25,000 bbls	$15,000,000	Under Constr	Aug 1960	.....	McKee/Parsons	McKee/Parsons
	E. Roxana, Ill.	Hydrotreater	25,000 bbls	$4,500,000	Complete	.....	.....	Procon	Procon
	Healdton, Okla.	Exp. Plant	.....	$315,000	Under Constr	.....	.....	Staff	Hudson
Sinclair Refining	East Chicago	Alkylation/LPG	5,000 bbls	.....	Under Constr	Late 1959	.....	Braun	Braun
Skelly Oil	El Dorado, Kan.	Gasoline Treater	7,000 bbls	.....	Under Constr	Late 1959	.....	Litwin	Staff
Standard-Indiana	Whiting, Ind.	Vapor Recovery	.....	.....	Under Constr	1960	.....	McKee	McKee
		Vacuum Distl. Tower	36,000 bbls	.....	Under Constr	3rd Qtr. 1959	.....	Braun	Staff
		Exp. Cat Cracker	10,000 bbls	.....	Engineering	1960	.....	Kellogg	Staff
	Wood River, Ill.	Cat Cracker	30,000 bbls	.....	Complete	.....	.....	McKee	McKee
Standard-Ohio	Lima, Ohio	Exp. Lube Wax Facilities	.....	$650,000	Under Constr	.....	.....	.....	.....
		Acrylonitrile	.....	.....	Under Constr	1960	.....	Badger Mfg	Badger Mfg
Sun Oil	Laverne, Okla.	Gas Products Recovery	100 MMcf	$4,000,000	Complete	.....	.....	Pritchard	Pritchard
	Toledo	Tank Gauging System	.....	$230,000	Complete	.....	.....	Staff	Staff
Sunray Mid-Continent	McClain County, Okla.	Natural Gasoline	5 Mmcf	$1,000,000	Under Constr	1959	.....	Pona	Pona
Texaco	Lawrenceville, Ill.	Cat Reformer	12,000 bbls	.....	Under Constr	4th Qtr. 1959	.....	Bechtel	Betchel
		Hydrotreater	12,000 bbls	.....	Under Constr	4th Qtr. 1959	.....	Bechtel	Bechtel
	Tulsa, Okla.	Alkylation	2,050 bbls	.....	Under Constr	4th Qtr. 1959	.....	Staff	Kaighin & Hughes
Union Carbide	Marietta, Ohio	Liquid epoxy resin	15,000,000 lbs/yr	.....	Under Constr	1959	.....	.....	.....
	Whiting, Ind.	Low-density Polyethylene	72,000,000 lbs/yr	.....	Under Constr	1959	.....	.....	.....
Vickers	Potwin, Kan.	Water Disposal	.....	$200,000	Under Constr	Dec 1959	.....	Wilson	Sherwood/Litwin
Warren Petroleum & Sunray	Forgan, Okla.	Gasoline	100 Mmscf	$3,000,000	Under Constr	1959	.....	.....	Dresser
Warwick Wax	Chanute, Kan	Waste Disposal	.....	.....	Engineering	Dec 1959	.....	Litwin	Litwin
		Vacuum Distl.	500 bbls	.....	Engineering	Dec 1959	.....	Litwin	Litwin
		Propane Deasphalting	350 bbls	.....	Engineering	Dec 1959	.....	Litwin	Litwin
Witco Chemical	Chicago	Phthalic Anhydride	20,000,000 lbs/yr	.....	Under Constr	1959	S D	S D	S D

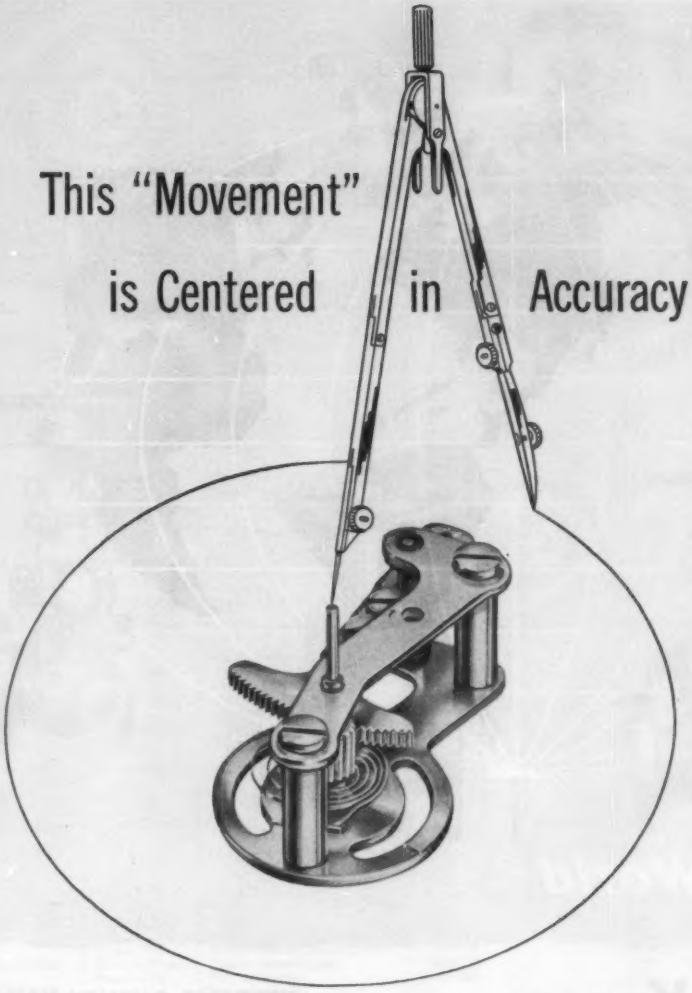
Southwest

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
American Cyanamid	Bridgerville, Pa.	Maleic Anhydride	14,000,000 lbs/yr	.....	Under Constr	Late 1959	SD	SD	SD
American Oil	Texas City	Relocated Delayed Coker	430 tons	.....	Planning	1959	.....	Tellepsen	Tellepsen

* First appearance in tabulation.

Construction BOXSCORE Continued on Page 207

This "Movement" is Centered in Accuracy



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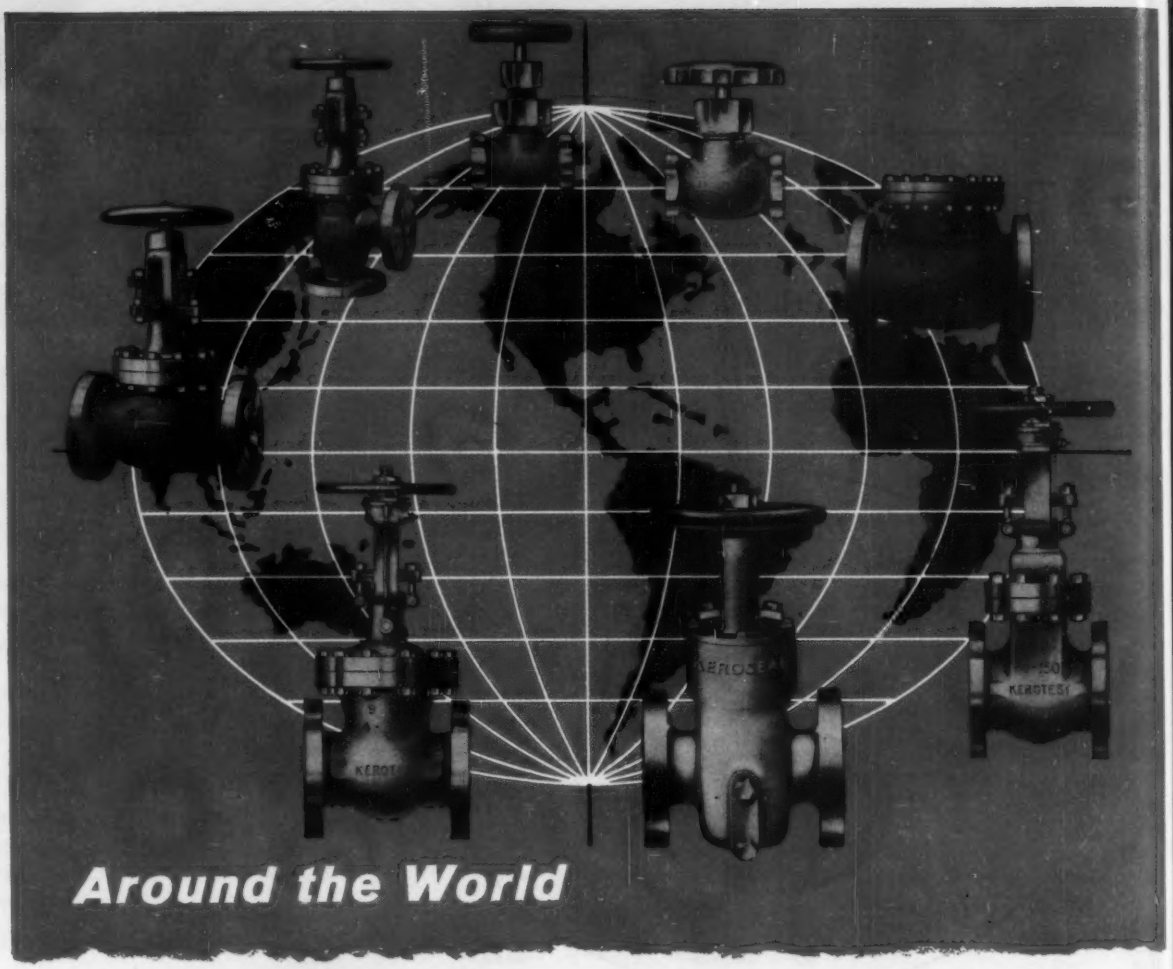

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CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Bay Petroleum	New Orleans	Alkylation	2,700 bbls	.....	Under Constr	Early 1960	UOP	Bechtel	Bechtel
		Exp Cat Cracker	15,000 bbls	.....	Engineering	Early 1960	UOP	UOP	Procon
		Crude	35,000 bbls	.....	Under Constr	Early 1960	.....	Bechtel	Bechtel
Carbide & Carbon	Seadrift, Texas	Exp. Ethylene Oxide	To 200,000,000 lbs/yr	.....	Planning	.....	.....	.....	.....
		Exp. Ethylene Glycol	To 65,000,000 lbs/yr	.....	Planning	.....	.....	.....	.....
Champlin O & R	Bishop, Texas	Gas Processing Exp.	22,000 Mmcf	$3,000,000	Complete	.....	.....	Fluor/Staff	Fluor/Staff
Copolymer Rubber & Chemical	Baton Rouge	Exp. Butadiene	35,000 short tons yr	.....	Under Constr	.....	.....	.....	.....
CM&M Gas Products	Wise County, Texas	*Exp. Gas Processing, Liquid Recovery	150 Mmcf	$700,000	Under Constr	Late 1959	.....	.....	.....
Delhi-Taylor	Corpus Christi, Texas	*Narrow Distillation Range Solvents	2,500 bbls	.....	Complete	.....	.....	.....	.....
Dow Chemical	Freeport, Texas	Acrylonitrile	.....	.....	Under Constr	.....	.....	.....	.....
		Polyethylene	.....	.....	Complete	.....	.....	.....	.....
	Plaquemine, La.	*Polyethylene	.....	$12,000,000	Planning	Mid 1961	ICI	.....	.....
		*Vinylidene	.....	.....	.....	.....	.....	.....	.....
		*Chloride	.....	.....	.....	.....	.....	.....	.....
		*Chlorothene	.....	.....	.....	.....	.....	.....	.....
Du Pont	Orange	Polyethylene	.....	.....	Under Constr	.....	.....	.....	.....
	Beaumont	Caprolactam	50,000,000 lbs/yr	.....	Planning	Late 1960	.....	Staff	Staff
	Near New Orleans	Petrochemical	.....	.....	Considering	.....	.....	.....	.....
El Paso Natural Gas	Crane, Texas	Exp. Compression and Treating	.....	$2,000,000	Under Constr	.....	.....	Olsen	Olsen
Firestone	Orange, Texas	Polyisoprene Polybutadiene	30,000 tons/yr	.....	Engineering	.....	.....	.....	.....
Gulf Oil	Anascosa County Texas	*Gas Sweetening & Dehydration	140 Mmcf	.....	Complete	.....	.....	B & R	B & R
		*Deisobutaniser	10,000 bbls	.....	Engineering	Early 1960	.....	Treco	Treco
	Port Arthur	*High Purity Ethylene	1,400,000 lbs	.....	Engineering	Summer 1960	.....	Kellogg/Gulf	Kellogg/Gulf
Humble	Baytown, Texas	Phenol Extraction for Cat Cracking feed	31,500 bbls	.....	Compelte	.....	.....	Kellogg/B & R	Staff
		Polyolefin	40,000 lbs/yr	.....	Under Constr	Jan. 1960	.....	Esso	Staff
	Rusk County, Texas	Remote Absorber	80 Mmcf	.....	Engineering	.....	.....	Staff	.....
	Kleberg County, Texas	Gas Process & Cycling	300 Mmcf	.....	Under Constr	1960	.....	Staff	Hudson
Koppers	Port Arthur	Exp. Polyethylene	.....	.....	Planned	.....	Staff	Staff	Staff
La Gloria Oil & Gas	Tyler, Texas	Gas Concentration; Revamp Cat Cracker	.....	.....	Under Constr	.....	UOP	UOP	B & R
	Acadia Parish, La.	*LPG	176 Mmcf	.....	Under Constr	Early 1960	.....	B & R	B & R
		*Natural Gasoline							
Magnolia	Beaumont, Texas	Cat Reforming	20,000 bbls	.....	Under Constr	1960	.....	Fluor	Fluor
		Ethylene	380,000,000 lbs/yr	.....	Under Constr	1961	.....	Kellogg	Kellogg
McBride Refining	Port Brownsville, Texas	Refinery Exp.	12,500 bbls	$2,500,000	Planned	.....	.....	.....	.....
Monsanto	Texas City	Exp Polyethylene	100,000,000 lbs/yr	.....	.....	Fall 1959	.....	.....	.....
Natural Gas Liquids	Orange County, Texas	*Refinery	20,000 bbls	$6,500,000	Under Constr	Oct 1960	.....	.....	.....
Pan American Pet.	Eclor County, Texas North Cowden	*Exp. Gas Compression	.....	.....	Under Constr	1959	.....	Staff	B & R
	Brazoria County, Texas	*Exp. Old Ocean	.....	.....	Engineering	Late 1960	.....	B & R	B & R
Phillips Chemical	Sweeney, Texas	Ethelyene	.....	.....	Under Constr	1959	.....	Staff	Staff
	Pasadena, Texas	Exp Methylvinylpyridine	.....	.....	Under Constr	1959	.....	Phillips	Phillips
	Borger, Texas	Multi Purpose Chemicals	.....	.....	Engineering	1959	.....	Phillips	Phillips
Phillips Petroleum	Sweeny, Texas	Hexane Isomerization	1,000 bbls	.....	Under Constr	1959	.....	Staff	Staff
	Kansas City	H.F. Alkylation	6,600 lbs	.....	Under Constr	1960	Phillips	Staff	Staff
Reichold Chemical	Huston	*Petrochemicals	.....	.....	Under Constr	1959	.....	B & R	B & R
Runnels Gas Products & Texas Gas Expl.	Eunice, La.	Gasoline Exp.	100 Mmcf	$500,000	Complete	.....	.....	Fluor	Staff
Shamrock Oil & Gas	Sunray, Texas	*TCC	8,000 bbls	.....	Under Constr	Spring 1960	.....	Fluor	Fluor
Shell Oil	Norco, La.	Cat Gasoline Fractionator	.....	$1,200,000	Complete	.....	.....	Foster Wheeler	Foster Wheeler
		Platformer	16,000 bbls	$7,500,000	Complete	.....	.....	Procon	Procon
	Deer Park, Texas	*Distillate Hydrotreater & Offsite Facilities	30,000 bbls	$3,500,000	Under Constr	Mid 1960	.....	Fluor	Fluor
	Weeks Island, La.	Nat. Gas Processing	120 Mmcf	.....	Plann ing	.....	.....	.....	.....
Shell Chemical	Norco, La.	Acrolein	.....	.....	Under Constr	.....	.....	.....	.....
		Glycerine	.....	$4,500,000	Under Constr	Late 1959	.....	Staff	Parsons/Fluor
	Houston	Phenol	.....	.....	Under Constr	Late 1959	.....	.....	Kellogg
Sinclair Refining	Hulldale Field, Texas	Desulfuriser	.....	.....	Under Constr	.....	.....	.....	.....
Spencer Chemical	Orange, Texas	Polyethylene Exp.	90,000,000 lbs/yr	.....	Under Constr	.....	.....	Staff	Quaker
Sunray Mid-Continent	Jackson County, Texas	Gas Recovery	30 Mmcf	$600,000	Complete	.....	.....	.....	.....
		Propane Isobutane Butane Natural Gasoline	27,000 gals	.....	Under Constr	.....	.....	.....	.....
	Bossier Parrish, La.	Exp Recovery Facilities	500 MMcf	$500,000	Planning	.....	.....	.....	.....
Texas Eastman	Longview, Texas	Exp. Oxo, Normal Butyraldehyde, Iso-butyraldehyde	125,000,000 lbs/yr	.....	.....	.....	.....	Staff	Hudson
Texas Gulf Producing	Ector-Midland Counties	*Natural Gas	.....	.....	Under Constr	1959	.....	B & R	B & R
		*Liquids & Compression							
Texas Natural Gasoline	.....	*CGT Gas Line	.....	.....	Planning	Early 1960	.....	.....	.....
		*Natural Gas Liquids							
Texaco	Port Arthur	Cat Reformer	20,000 bbls	.....	Under Constr	1959	.....	UOP	Staff & Fluor
		Udex	28,000 bbls	.....	Under Constr	1959	.....	UOP	Staff & Fluor
	El Paso	Alkylation	1,600 bbls	$250,000	Under Constr	4th Qtr. 1959	.....	Texaco	Sweco
Texas Alkyls	Houston	*Detergents	.....	.....	Under Constr	Late 1960	.....	Staff	B & R
		*Special Chemicals	.....	.....	.....	.....	.....	.....	.....
Tidewater Oil	Franklin County Texas	*Cycling	50 Mmcf	.....	Engineering	Early 1960	.....	B & R	B & R
		*Natural Gasoline							
		*Sulfur Recovery	250 tons	.....	Engineering	Early 1960	.....	B & R	B & R
Transwestern Pipeline	Pecos County,	*Gas Treating	180 Mmcf	.....	Under Constr	Late 1959	Giammarco-Vetrocoke	B & R	B & R
Union Carbide	Seadrift. Texas	Ester & Alcohol	100,000,000 lbs/yr	.....	Design	1960	.....	.....	.....
		*Exp. Petrochemicals	.....	.....	Under Constr	Late 1959	.....	Staff	B & R
United Rubber & Chemical	Baytown, Texas	Synthetic Rubber	.....	.....	Under Constr	.....	.....	Day & Zimmerman	Tellepsen
U.S.I.C.	Houston	*Exp. Polyethylene	75,000,000 lbs/yr	.....	Under Constr	Mid 1960	ICI	Kellogg	Kellogg

* First appearance in tabulation

Construction BOXSCORE Continued on Page 208

CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Western Nat. Gas....	Brownsville, Texas	Refinery Revamp							
	Hidalgo County, Texas	Gasoline Extraction							
	Victoria County, Texas	Gasoline Extraction	3,500 bbls	.....	Under Constr	.....	.....	.....	.....
	Aransas County, Texas	Gasoline Extraction							

Rocky Mountain

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
American Gilsonite...	Grand Junction, Colo.	Coking Exp	1,100 tons	.....	Engineering	.....	.....	Foster Wheeler	.....
El Paso Natural Gas	Jal, N. M.	Exp. Gasoline Fractionation	1,000 Mmcf	$2,471,000	Engineering	1959	.....	Delta	Delta
		Fractionation	452,000 gals	$730,000	Under Constr	1959	.....	Stearns-Roger	Bowden
		*Compressor							
		*Gasoline Treating	175 Mmcf	$7,000,000	Under Constr	1959	.....	Delta	Delta
		*Dehydration							
		*Liquid Product	.....	.....	.....	.....	.....	.....	.....
		*Treating, Fractionation	312,000 gals	$2,700,000	Under Constr	1959	.....	Stearns-Roger	Bowden Constr
		Natural Gasoline Absorption	.....	$2,500,000	Under Constr	1959	.....	Delta	Delta
	San Juan, Utah	Gasoline	1,500 Mmcf	$5,378,000	Planning	.....	.....	Fish	Fish
		*Natural Gasoline	100 Mmcf	$5,600,000	Under Constr	Nov 1959	.....	Fish	Fish
Pan American.....	Riverton, Wyo.	Gasoline	.....	$1,000,000	Under Constr	1959	.....	Olsen	Olsen
Southwestern Agro-chemical	Chandler, Ariz.	Ammonia Synthesis	60 tons	$5,000,000	Engineering	Jan. 1960	.....	.....	.....
Texaco.....	San Juan County, Utah	Gasoline	.....	.....	.....	.....	.....	.....	.....

West Coast

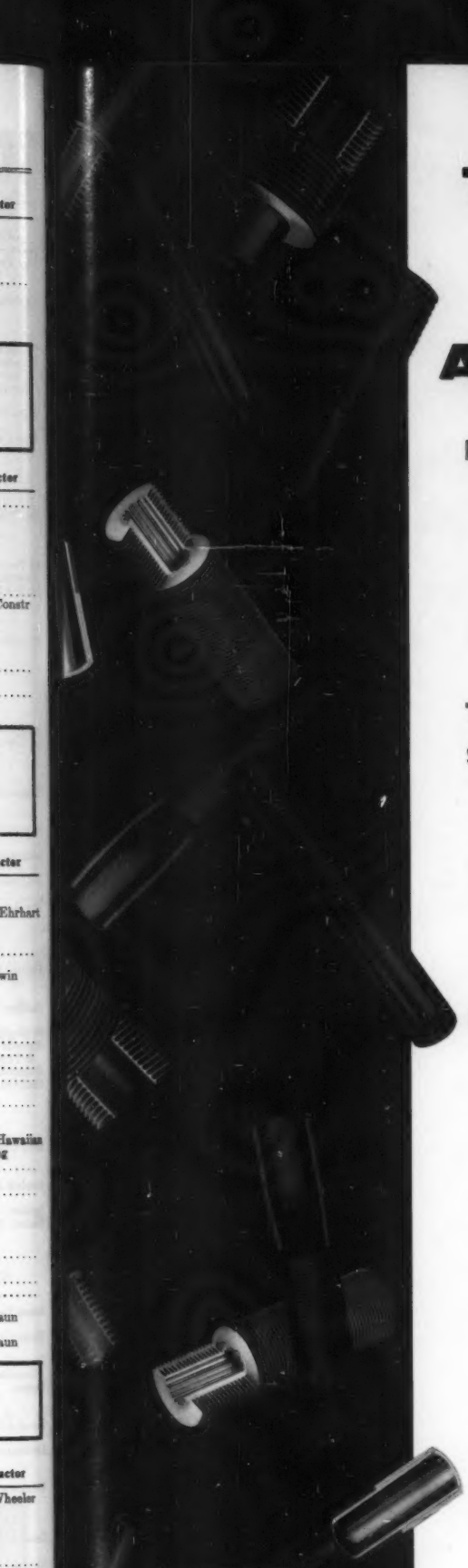
COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
American Chem.....	Watson, Cal.	Chemical	.....	.....	Under Constr	Late 1959	.....	Braun	Braun
California Ammonia..	Lathrop, Cal.	Ammonia Synthesis	100 tons	$5,000,000	Engineering	1959	.....	Macco	Macco
Collier Carbon & Chemical	Brea, Cal.	*Exp. Ammonia	$1,000,000	.....	Complete	.....	.....	Braun & Ehrhart	Braun & Ehrhart
		Ammonia Exp.	.....	.....	Under Constr	1959	.....	Braun	Ehrhart
du Pont.....	Antioch, Cal.	Fluorinated Hydrocarbons, Tetraethyl Lead	.....	.....	Under Constr	.....	.....	.....	.....
Empire Petroleum....	Denver	*Vacuum Rerun	1,150 bbls	$50,000	Complete	.....	.....	Staff/Litwin	Staff/Litwin
General Petroleum....	Torrance, Cal.	Exp Delayed Coker	9,300 bbls	.....	Under Constr	Feb 1960	.....	Bechtel/Staff	Bechtel
		Exp. Platinum Cat Cracker	8,000 bbls	.....	Complete	.....	.....	Braun/Staff	Braun
Vally Nitrogen.....	Cal.	Ammonia	150 tons	.....	Engineering	1959	Chemico	Chemico	Chemico
Richfield.....	Watson, Cal.	*Gas Plant Revamp	.....	.....	Under Constr	Late 1959	.....	Braun	Braun
		*General Facilities Revamp	.....	.....	.....	.....	.....	.....	.....
Shell Development....	Emeryville, Cal.	Research Lab.	.....	$500,000	Under Constr	.....	.....	.....	.....
Shell Oil.....	Wilmington	Boiler for Cat Cracker	200,000 lbs	$1,000,000	Complete	.....	.....	.....	.....
Signal Oil & Gas.....	Huntington Beach Cal.	*Refinery	40,000 bbls	$40,000,000	Engineering	.....	.....	.....	.....
	Bakersfield, Cal.	*Exp. Refinery	15,000 bbls	.....	Engineering	.....	.....	.....	.....
Standard Oil (Calif.)..	El Segundo	Steam Generating	275,000 lbs/hr	$2,000,000	Complete	.....	.....	Fluor	Fluor
	Richmond, Cal.	FCC	40,000 bbls	$33,000,000	Complete	.....	.....	Fluor	Fluor
	Honolulu	Refinery	35,000 bbls	$40,000,000	Under Constr	1961	.....	Staff/Bechtel	Bechtel/Hawaiian Dredging
Union Oil.....	Wilmington, Cal.	*Unifiner-Reformer	14,000 bbls	.....	.....	.....	.....	.....	.....
		*Mid-Barrel Unifiner	20,000 bbls	$17,000,000	Engineering	Fall 1960	Union Oil/ Sinclair/ Baker	Braun	Braun
		*Heavy Cat Unifiner	4,000 bbls	.....	.....	.....		.....	.....
		*CO Boiler	240,000 lbs/hr	$2,500,000	Engineering	Late 1960	.....	Fluor	Fluor
		*Amine Reactivator	150 tons	.....	.....	.....	.....	.....	.....
		*Sulfur	.....	$2,000,000	Engineering	Spring 1960	.....	Parsons	Parsons
		*H_2S Recovery	67 tons	.....	.....	.....	.....	.....	.....
Wilshire.....	Norwalk, Cal.	Crude Distillation Revamp	.....	.....	Under Constr	.....	.....	Braun/UOP	.....
		*HF Alkylation	.....	.....	Engineering	Spring 1960	UOP	Braun/UOP	Braun
	Santa Fe Springs, Cal.	*Crude Distillation Revamp	.....	.....	Under Constr	Fall 1959	.....	UOP/Braun	Staff/Braun
		*Alkylation	1,500 bbls	.....	Engineering	Spring 1960	UOP	UOP/Braun	Staff/Braun

Canada

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
British American Oil..	Clarkson, Ont.	Compounding, Blending & Grease	.....	$2,900,000	Under Constr	.....	.....	Nofsinger	Foster Wheeler
		*Exp. Cat Cracker	6,000 bbls	$1,500,000	Complete	.....	.....	Kellogg	Kellogg
		*Alkylation	3,000 bbls	$3,000,000	Under Constr	1960	UOP	UOP	Procon
		*Steam Generating Revamp	.....	$600,000	Complete	.....	.....	Staff	Staff
	Calgary	*Exp. Reformar	3,000 bbls	$500,000	Under Constr	1959	.....	Treco	Treco
	Moose Jaw Sask.	*Cat Reformer	5,400 bbls	.....	.....	.....	.....	.....	.....
		*HDS Gas Splitter	7,000 bbls	$3,900,000	Complete	.....	Atlantic/ UOP	Lummus/Procon	Lummus/Procon

* First appearance in tabulation.

Construction BOXSCORE Continued on Page 211



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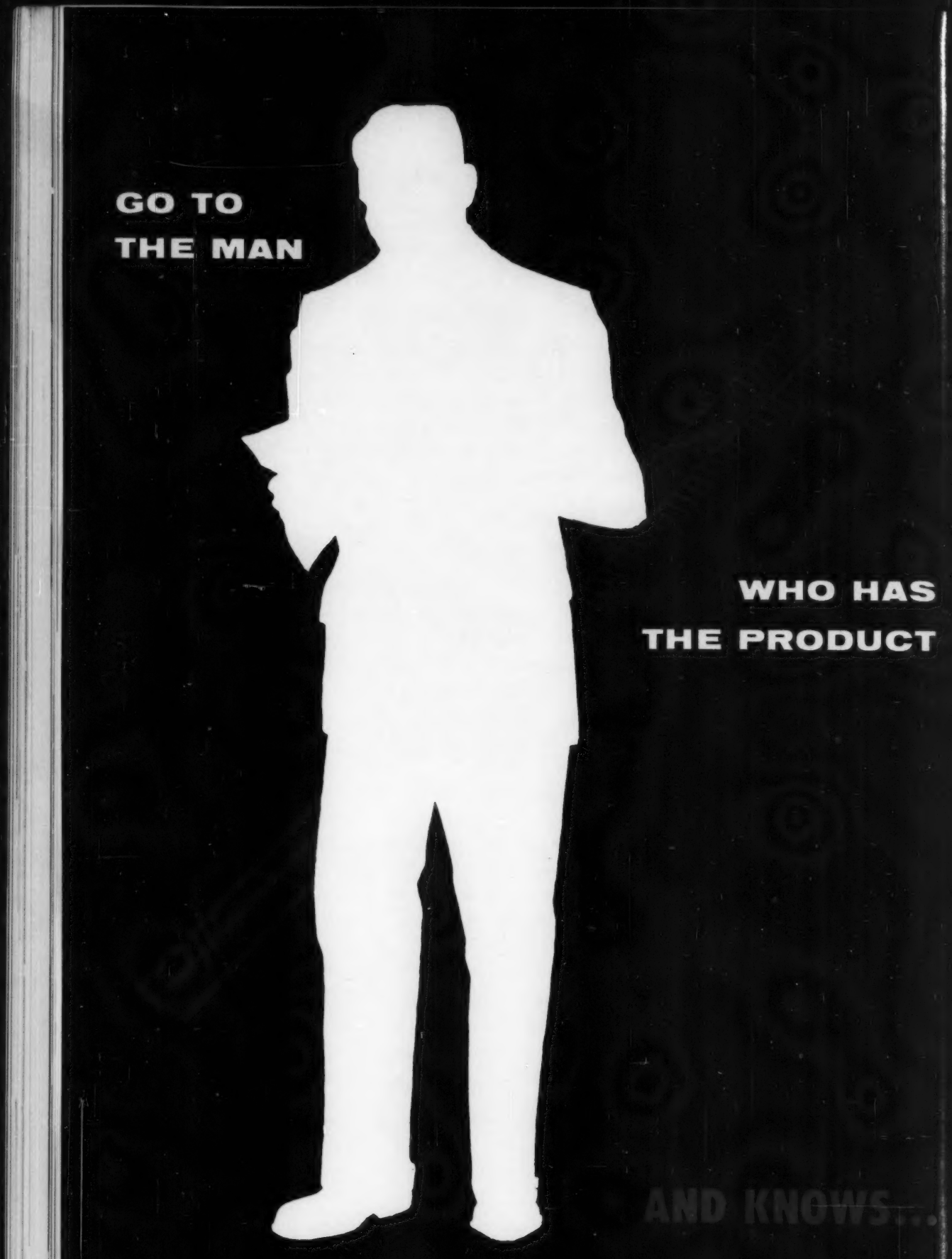
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CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
British Petroleum	Ville d'Anjou	Crude Distl	25,000 bbls	.....	Under Constr	Spring 1960	.....	Lummus	Lummus
		Cat Cracker	9,000 bbls	.....	Under Constr	Spring 1960	UOP	Lummus	Lummus
		Platformer	6,000 bbls	.....	Under Constr	Spring 1960	UOP	Lummus	Lummus
		Cat Desulfuriser	12,000 bbls	.....	Under Constr	Spring 1960	.....	Lummus	Lummus
		Cat Polymerisation	700 bbls	.....	Under Constr	Spring 1960	UOP	Lummus	Lummus
Canadian Industries	Edmonton, Alb.	Exp. Polythene	40,000,000 lbs/yr	.....	Complete	.....	.....	.....	Poole Constr
Canadian Oil	Corunna, Ont	Crude Distl.	20,000 bbls	$3,000,000	Complete	.....	.....	Kellogg	Kellogg
		Steam Boiler	150,000 lbs/hr	.....	Complete	.....	.....	John Thompson/ Leonard	John Thompson/ Leonard
		Unifiner	5,000 bbls	.....	Under Constr	Oct 1959	.....	UOP	Procon
Canadian Petrofina	Montreal	Exp. Capacity	30,000 bbls	$5,000,000	Under Constr	.....	.....	Staff	Procon (Canada
Carstairs Operators Committee	Carstairs, Alb.	*Gas Processing	66 Mmcf	$3,500,000	Under Constr	Spring 1960	.....	Fluor	Fluor
Cities Service	Trafalgar, Toronto	*Coker, Gas Compressor	6 Mmcf	$400,000	Complete	.....	.....	UOP	Procon
Consolidated Smelting	Calgary, Alb.	*Refinery	20,000 bbls	$27,000,000	Complete	.....	.....	Staff/Braun	Staff/Braun
		*Urea	100 tons	.....	Engineering	Mid 1960	Inventa-Vulcan	Vulcan	Comineo
Cyanamid of Canada	Welland, Ont.	Nitric Acid	190 tons	.....	Engineering	1960	Uhde	McKee	McKee
Devon-Palmer & Texas Gulf Sulfur	Calgary, Alb.	Sulfur Extraction	400 tons	$8,000,000	Planning	1959	.....	.....	.....
Imperial Oil	Sarnia	Refinery Exp.	94,000 bbls	$5,380,000	Under Constr	1959	.....	Staff	Staff
	Edmonton, Alb.	Alkylation	1,500 bbls	$2,175,000	Engineering	Feb 1960	.....	.....	.....
	Regina	Powerformer	3,000 bbls	$2,550,000	Under Constr	1959	.....	Canadian Kellogg	Canadian Kellogg
	Winnipeg	Alkylation	650 bbls	$2,000,000	Under Constr	1959	.....	Canadian Bechte	Canadian Bechtel
Irving Refining	St. John, New Brunswick	Hydrogen	.....	.....	Engineering	1960	.....	Girdler Bechtel	Canadian Bechtel
		Crude Desalter	38,500 bbls	.....	Under Constr	Dec. 1959	Howe-Baker	Bechtel	Bechtel
		Gas Treating-Sulfur Recovery	.....	.....	Engineering	1959	.....	Parsons	.....
		*Refinery	40,000 bbls	$45,000,000	Under Constr	1960	.....	Canadian Bechtel	Canadian Bechtel Fluor
Nevis Operators Committee	Nevis, Alb.	Gas Processing	43 Mmcf	$3,000,000	Under Constr	1959	.....	Fluor	Fluor
		Sulfur Recovery	125 tons						
Nottingham Gas Carnduff Gas	Saskatchewan	Gas Processing Treating, Gathering	8.5 Mmcf	.....	Engineering	1959	.....	Tellepsen	Tellepsen
Shell Oil (Canada)	Bronte, Ont.	Refinery	.....	.....	Planning	.....	.....	Treco/Staff	.....
Sogenines	Maitland, Ont.	*Synthetic Nitrogen, Ammonium Nitrate, Nitrogen Solutions, Anhydrous Ammonia	.....	$17,000,000	Planning	1961	.....	.....	.....
Steelman Gas	Southeast Saskatchewan	Natural Gas	25 Mmcf	$6,500,000	Under Constr	.....	.....	Stearns-Roger	Treco
Sun Oil	Sarnia	*Visbreaking	.....	$343,000	.....	Late 1959	.....	Staff	.....
Texco, Canada	Montreal	Sulfuric Acid Alkylation Feed Preparation and Treating	2,200 bbls	.....	Engineering	.....	.....	Foster Wheeler	Foster Wheeler
Texas Gulf Sulfur & Devon-Palmer	Okotoba, Alb.	*Sulfur Recovery	370 tons	.....	Complete	.....	.....	B & R	B & R
Westcoast Transmission	Coleman, Alb.	Gas Processing	.....	$15,000,000	Planning	.....	.....	.....	.....

Latin America

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
ARGENTINA									
Argentine Government	Santa Fe Province	Naphtha Reforming	.....	.....	Planning	.....	.....	.....	.....
Carbometal	Mendoza	Polyvinyl Choride	4,500 tons/yr	.....	.....	.....	.....	.....	.....
		Acetylene	200 tons/yr	.....	.....	.....	.....	.....	.....
		Plastics	7,500 tons/yr	.....	Planning	.....	Monsanto	Monsanto	Monsanto
Monsanto	Buenos Aires	Phthalic Anhydride	.....	.....	Under Constr	.....	.....	Foster Wheeler	.....
BRAZIL									
North American Solvay	Sao Paulo	Ethylene Purification	20 tons	.....	Under Constr	1959	.....	Hydrocarbon	Hydrocarbon/ SETAL
Petroleo Brasileiro	Mataripe	Atmospheric & Vacuum Distl. Cat Cracker Gas Recovery, Wax Treating, Lube	37,000 bbls	.....	Under Constr	1960	Kellogg	Kellogg	Kellogg/Brasileira/Montreal, S A
	Rio de Janeiro	Refinery	90,000 bbls	$60,000,000	Under Constr	1961	.....	Foster Wheeler	.....
	Duque De Caxias Estad. Do Rio de Janeiro	*Synthetic Rubber	40,000 tons	.....	Engineering	1962	.....	.....	.....
	Cubatao-Sao Paulo	Exp. Refinery	90,000 bbls						
		Cat Reformer	12,000 bbls	$10,000,000	Planning	Mid 1962	.....	.....	.....
		Aromatics Extr.	3,000 bbls						
		Ethane Cracking	3.77 MMcf						
Uhde	Cubatao	Urea	.....	.....	.....	.....	.....	Uhde	Uhde
Union Carbide	Cubatao	Polyethylene	.....	.....	Under Constr	.....	.....	B & R	B & R
CHILE									
Empresa Nacional del Petroleo	Concon	Refinery Exp:							
		Crude Topping	24,000 bbls						
		Vacuum	10,080 bbls						
		Orthoflow FCC	12,000 bbls	$15,000,000	Under Constr	Late 1959	Kellogg	Kellogg	Staff & Kellogg
		SBK Cat Reforming and Desulfurization	6,000 bbls						
		Alkylation	1,100 bbls						
COLOMBIA									
Empresa Colombiana de Petroleos	Barranca-Bermeja	Exp. Propane Recovery	1,000 bbls	$1,000,000	Planning	.....	.....	.....	.....
	El Centro	*Natural Gasoline	51.4 Mmcf	$2,700,000	Under Constr	Oct 1959	.....	Parsons	Parsons
ECUADOR									
Anglo-Ecuadorian Oilfields	Santa Elena	Atomspheric Distl.	7,700 bbls	$4,500,000	Under Constr	Early 1960	UOP	Procon	Procon
	Ancon	Thermal Cracking	6,000 bbls	.....	Under Constr	.....	UOP	Procon	Procon
GUATAMALA									
Breaux Oil Refg	Bridge Puerto Barrios	Refinery	4,000 bbls	.....	Planning	.....	.....	Lummus	Lummus

* First appearance in tabulation.

Construction BOXSCORE Continued on Page 212

CONSTRUCTION BOXSCORE—*Continued*

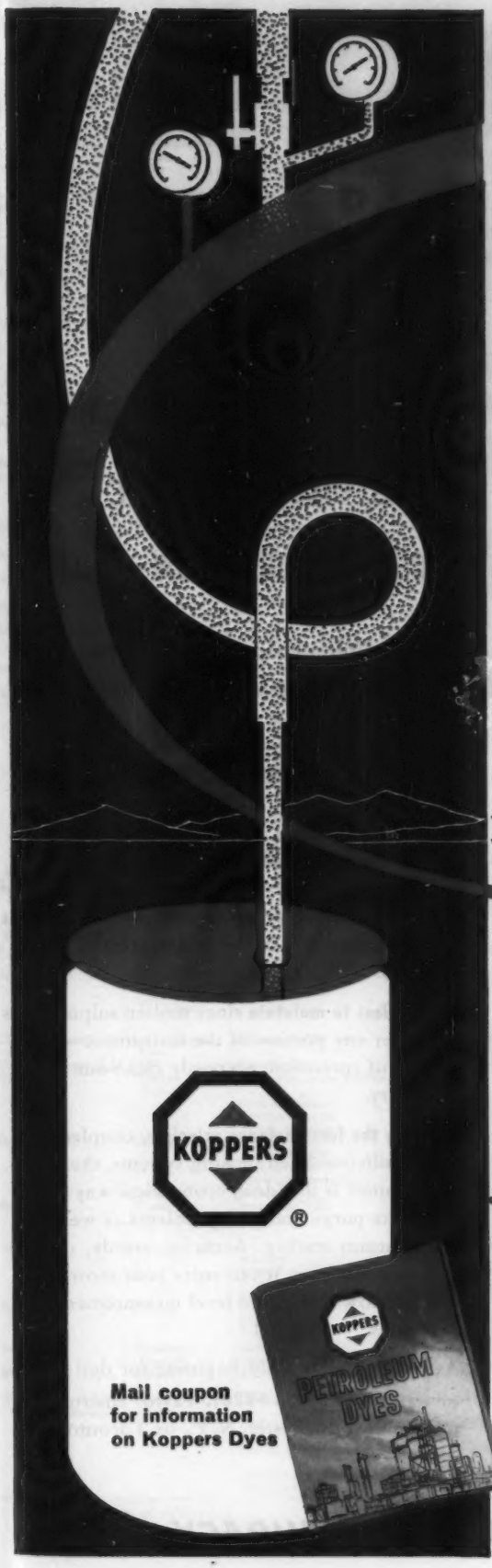
COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
MEXICO									
Pemex	Minatitlan	*Anhydrous Ammonia,	200 tons	$8,000,000	Engineering	Late 1960	.....	Fluor	Fluor
		*Crude, Cat Cracking, BTX	27,000 bbls	$23,000,000	Engineering	Mid 1961	UOP	Fluor	Fluor
	Atzcapotsalco	*Dodecilbencene	40.5 tons	$2,000,000	Under Constr	Dec 1959	UOP-Phillips	McKee	McKee
	Salamanca	*Anhydrous Ammonia	200 tons	$8,000,000	Engineering	Late 1961	.....	Lummus	Lummus
		*Cat Cracking, Exp. Refinery	20,000 bbls	$13,000,000	Engineering	Late 1961	TCC Socony	Lummus	Lummus
		*Grease	25 tons	$2,100,000	Engineering	Mid 1961	.....	McKee	McKee
	C. Madero	*Topping, Cat Cracking Gas Recovery	1110,000 bbls	$43,000,000	Under Constr	Mid 1960	ICOP, Esso, UOP	McKee	McKee
	Posa Rica	*Topping	15,000 bbls	$5,000,000	Under Constr	Late 1960	.....	McKee	McKee
NETHERLANDS ANTILLES									
Lago Oil & Transport	Aruba, N. A.	Revamp Distl. & Visbreaking	.....	.....	Under Constr	Nov. 1959	.....	Kellogg	Kellogg
PANAMA									
Refiner a Petroquimica de Panama	Portobelo	Refinery	55,000 bbls	$40,000,000	Engineering	1961	.....	Foster Wheeler	Foster Wheeler
Refineria Panama, S A	Las Minas Bay Colon	Refinery; Petrochemicals	70,000 bbls	$50,000,000	Under Constr	Late 1960	.....	Kellogg	.....
PARAGUAY									
Compagnie Fives-Lille	Asuncion, Paraguay	Refinery	10,000 bbls	.....	Planning	.....	.....	.....	.....
PUERTO RICO									
Commonwealth Oil Refining	Guayanilla Bay	Unifiner	7,500 bbls	$1,200,000	Complete	.....	UOP	UOP	Procon
		Ref. Modifications	75,000 bbls	$6,500,000	Under Constr	1959	.....	UOP	Procon-Others
Union Carbide Caribe	Ponce	Ethylene-Glycol	500,000 lbs	$28,500,000	Planning	1959	.....	B & R	B & R
TRINIDAD									
Federation Chemicals,	Point Lisas	Nitrogen	100 tons				Kellogg	Braun/Kellogg	Braun
		Urea	70 tons				Stamicarbon	Braun	Braun
		Ammonia	100 tons					Kellogg	Braun
		Sulfuric Acid	200 tons	$12,000,000	Under Constr	1959	Monsanto	Leonard	Braun
		*Ammonium Sulfate	245 tons				Stami-Carbon	Braun	Braun
Texaco Trinidad	Pointe-a-Pierre	Crude Distl.	15,000 bbls	.....	Under Constr	.....	UOP	Procon	Procon
URUGUAY									
Administracion	Montevideo	Crude Desalter	28,000 bbls	$12,000,000	Under Constr	Late 1959	Howe-Baker	Kellogg/Staff	
Nacional de Combustibles Alcohol Y Portland		Vac. Distl.	10,000 bbls	.....	.....	.....			
		Cat Cracker	5,000 bbls	.....	.....	.....			
		Cat Reformer	3,000 bbls	.....	.....	.....			
		Gas Concent. & Bottling	.....	.....	.....	.....		Kellogg-/Staff	Staff
		Gas Sweetening	4,500 bbls	.....	.....	.....			
		Sulfur Recovery	6 tons	.....	.....	.....			
		Power & Offsite Facil.	3,600 KW	.....	.....	.....			
VENEZUELA									
Cia Shell	Cardon	Distl.	80,000 bbls	$20,000,000	Under Constr	.....	.....	.....	.....
		Alkylation	2,800 bbls	.....	Under Constr	.....	.....	.....	.....
Creole Pet.	Amuay Bay	Naphtha Fractionator	45,000 bbls	$3,600,000	Complete	.....	.....	Esso	Lummus
Mene Grande Oil	Eastern Venezuela	*Compressor Stations	.....	.....	Engineering	Early 1960	.....	B & R	.....
Socony Mobil	El Palito	Refinery	50,000 bbls	$28,000,000	Under Constr	Late 1959	.....	Kellogg	Kellogg
	Eastern Venezuela	*Compressor Stations	.....	.....	Engineering	Early 1960	.....	B & R	.....
Venezuela Gulf Refg.	Puerto la Cruz	Crude Distl.	65,000 bbls	.....	Under Constr	Late 1959	.....	Foster Wheeler	Foster Wheeler

Europe and Africa

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
AUSTRIA									
Austrian Oil Administration	Schwechat near Vienna	Crude Distl. Cat Reformer, Gas Recovery, Chemical	35,000 bbls 7,000 bbls	$22,300,000	Engineering	Late 1959	.....	Lurgi	Lurgi
Danubia Petrochemie A. G.	Schwechat near Vienna	Polypropylene	11,000,000 lbs/yr	.....	.....	.....	.....	.....	.....
BELGIUM									
AE & CI	Modderfontein	*Synthetic Ammonia	70,000 tons	.....	Under Constr	1960	.....	AE & CI/ICI/PGC	Power-Gas
British Chrome & Chemicals	Urlay Nook	*Sulfuric Acid	100 tons	.....	Under Constr	1959	Chemiebau	Power-Gas	Power-Gas
Carbochimique	Tertre	*Partial Oxidation Synthesis Gas	100-500 tons NH_3	.....	Under Constr	1959	Texaco	Power-Gas	.....
		*High Pressure CO Conversion	100-150 tons NH_3	.....	Under Constr	1959	Texaco	Pgwer-Gas	Power-Gas
Cobenam, S.A.	Antwerp	Polyethylene	15,000 tons/yr	.....	Planning	Mid 1960	.....	Union Carbide	Union Carbide
Qatar	Qatar	*CO_2	50 lbs/hr	.....	Under Constr	1959	Girdler	Power-Gas	Power-Gas
CANARY ISLANDS									
Cepsa	Las Palmas	Ammonia	90 tons	.....	Engineering	.....	Hoechst	Uhde	Uhde
		Ammonium Sulfate	365 tons	.....	Engineering	Mid 1960	Uhde-Texaco	Uhde	Uhde
ENGLAND									
Esso Petroleum	Milford Haven	Atmospheric Distl	100,000 bbls						
		Powerformer	16,500 bbls						
		Hydrofiner	16,500 bbls	.....	Under Constr	Late 1960	.....	Foster Wheeler	Foster Wheeler
		Electric Coalescer	31,500 bbls						
		Other Auxiliaries	.....						
Eastern Gas Board	Ponders End	*Catalytic Oil Gasification	7.4 Mmcf	.....	Complete	.....	.....	Power-Gas	Power-Gas
Imperial Chemical Industries	Billingham	Electrostatic Desulfurisation	1,150 bbls	.....	Under Constr	1959	Howe-Baker	Kellogg	Kellogg
Laporte Chemicals	Warrington	*Hydrogen	.....	.....	Complete	.....	Hercules	Power-Gas	Power-Gas
Malta Gas Board	Valetta	Catalytic Oil Gasification	1 Mmcf	.....	Under Constr	1959	.....	Power Gas	Power Gas
Mobil Oil Co., Ltd.	Coryton	Crude Unit Exp.	5,000 bbls	.....	Under Constr	.....	.....	Staff	Staff
Monsanto	Newport	Maleic Anhydride	15,000,000 lbs/yr	.....	Under Constr	Late 1960	SD	SD	SD
Northern Gas Board	Darlington	*Catalytic Oil Gasification	2 Mmcf	.....	Under Constr	.....	.....	Power-Gas	Power-Gas
North Thames Gas Board	Romford	Refinery Tail Gas Reforming	36 Mmcf	.....	Under Constr	.....	.....	H & G	H & G
North Western Gas Board	Manchester Partington	Pressure Oil Gasification	7.5 Mmscf	.....	Engineering	Dec. 1959	Texaco/others	H & G	H & G
Petrochemicals	Partington, Nr. Manchester	Exp. Ethylene	30,000 tons/yr	.....	Engineering	.....	.....	H W P	H W P
	Partington	Ethylene Oxide	25,000 tons/yr	.....	.....	.....	.....	.....	.....
Shell Refining	Shell Haven	Hydrodesulfuriser & Gerboto Modifications	.....	.....	Under Constr	1959	.....	Lummus	Lummus
		Hydrodesulfuriser	16,000 bbls	.....	Projected	1960	.....	.....	.....
	Stanlow	Udex	.....	.....	.....	.....	UOP	.....	.....

* First appearance in tabulation.

Construction BOXSCORE Continued on Page 215



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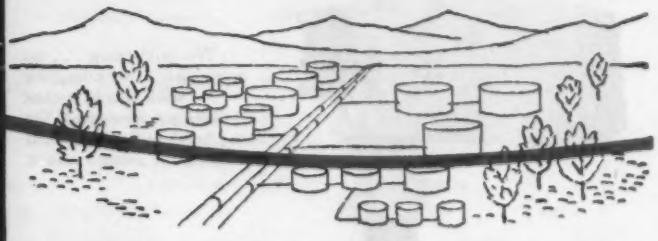

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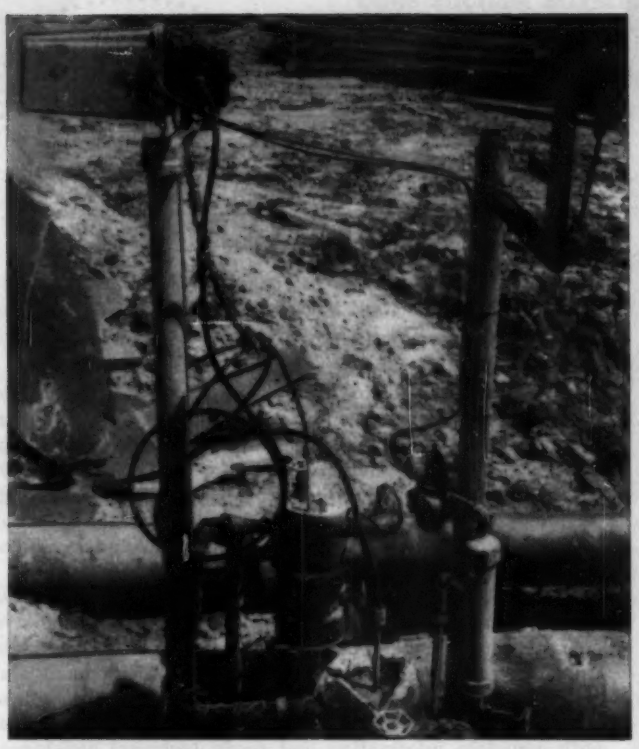
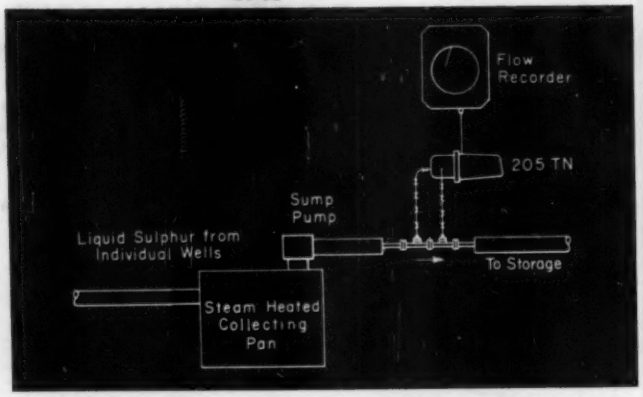


205T Volumetric Differential Pressure Transmitter measuring molten sulphur flow at Freeport Sulphur Company's mines in Louisiana.

Freeport Sulphur Company saves time, money on molten sulphur flow control

Taylor Volumetric DP Transmitter costs less to install and maintain

No pocketing . . . no purging . . . no plugging . . . with this low-cost transmitter designed for flow, level and differential pressure measurement.



Two all-welded stainless steel sensing diaphragms installed in the pipeline eliminate the need for steam tracing of the lead lines. Result—quicker, less expensive installation; negligible maintenance; process shut-down eliminated.

The Taylor 205T Transmitter costs less to install because none of the steam jacketing and insulation needed for a conventional aneroid meter is required. There is no need to insulate leads or meter body, since sulphur comes in contact only with the pressure sensitive diaphragms located either side of the orifice plate in the pipeline.

It costs less to maintain since molten sulphur does not enter any portion of the instrument—no chance of corrosion, no costly clean-out necessary.

Utilizing the force-balance principle, coupled with sealed silicone-filled sensing systems, the 205T Transmitter is the ideal, economical way to eliminate purge and seal problems as well as costly steam tracing. Accurate, sturdy, dependable and low-cost, it can solve your most difficult flow and liquid level measurement problems.

Ask your Taylor Field Engineer for dull details, or write for **Bulletin 98281.** Taylor Instrument Companies, Rochester, N.Y., or Toronto, Ont.

Taylor Instruments **MEAN ACCURACY FIRST**

CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
South Eastern Gas	Isle of Grain	Hydrogen	18 MMcf	.....	Under Constr	Late 1960	.....	Woodall-Duckham	Woodall-Duckham
		*Catalytic Oil Gasification	20 Mmcf	.....	Complete	.....	.....	Power-Gas	Power-Gas
Southern Gas Board	Southampton	Refinery Tail Gas Reforming	16 Mmcf	.....	Under Constr	.....	.....	H & G	H & G
	Reading	Catalytic Oil Gasification	7 Mmcf	.....	Under Constr	1959	.....	Power Gas	Power Gas
Union Carbide	Fawley	*Ethylene Oxide & Derivatives	.....	.....	Under Constr	.....	.....	.....	.....
FRANCE									
Compagnie de Raffinage Shell Berre	Petit Couronne	Distl.	80,000 bbls	.....	Under Constr	.....	.....	.....	.....
		Hydrodesulfuriser	11,000 bbls	.....	Under Constr	4th Qtr. 1959	.....	.....	.....
		Platformer	14,000 bbls	.....	Engineering	1959	.....	Procon	Procon
	Berre l'Etang	Furfural	3,500 bbls	.....	Under Constr	.....	.....	Foster Wheeler	Foster Wheeler
Comp Francaise de Raffinage	Gonfreville l'Orcher	Ethylene	30,000 tons/yr	.....	Under Constr	1959	.....	KIC	.....
Compagnie Francaise de Petrole; Compagnie Francise de Raffinage; Pechelbronn	Strasbourg	Refinery	70,000 bbls	.....	Planning	.....	.....	.....	.....
Esso Standard	Port Jerome	Powerformer	11,900 bbls	.....	Under Constr	.....	Esso	Foster Wheeler	Foster Wheeler
		Steam Cracker	5,000 bbls	.....	Under Constr	1959	Esso	Foster Wheeler	Foster Wheeler
		Dodecylbenzene	13,500,000 tons/yr	.....	Under Study	.....	Esso	Foster Wheeler	Foster Wheeler
Houilleres du Bassin de Lorraine	Carling	Acetylene	.....	.....	Under Constr	.....	.....	SBA	SBA
		Styrene Monomer	.....	.....	Under Constr	1959	.....	SBA	SBA
Manufacture Normande de Polyethylene	Gonfreville	Polyethylene	.....	.....	Under Constr	.....	Phillips	.....	S T E C
Marles-Kuhlmann	Gonfreville	Ethylene Oxide	.....	.....	Under Constr	.....	S D	Staff	.....
Mobil Oil Francaise	Gravenchon	Lube Exp.	.....	.....	Engineering 2nd phase	.....	.....	.....	.....
					Planning 3rd phase	1959	.....	.....	.....
Naphtachimie	Lavera	Ethylene Oxide Exp.	31,000,000 lbs/yr	.....	Engineering	.....	SD	SFST	SFST
		Expand Ethylene Oxide	31,000 lbs/yr	.....	Engineering	1960	SD	SFST	SFST
Omnium Francais de Petroles		Refinery	75,000 bbls	.....	Planning	.....	.....	.....	.....
Potasse et Engrais Chimiques	Grand Coronne	Ammonia	.....	.....	.....	.....	.....	Kellogg	Kellogg
Societe Coautchouc Butyl	Port Jerome	*Butyl Rubber	20,000 tons/yr	.....	Complete	.....	.....	CTIP-Braun	CTIP-Braun
Societe des Produits d'Aquitaine	.....	Ammonia	200 tons	$6,000,000	Engineering	1959	.....	Chemico	Chemico
	Lacq	Acetylene from Nat. Gas	75 tons	.....	Under Constr	.....	.....	BASF	.....
Soc. Francaise des Petroles BP	Lavera	Selective Hydrogenation	3,500 bpsd	.....	Engineering	April 1960	.....	.....	Technip
Soc. Nationale des Petroles D'Aquitaine	Lacq	Desulfurization	140 Mmcf	.....	Under Constr	.....	.....	Foster Wheeler Soc Chimique/	Foster Wheeler Soc Chimique
		Desulfurization	175 Mmcf	.....	Engineering	1959	.....	Foster Wheeler Soc Chimique/	Foster Wheeler Soc Chimique
		Distillation Recovery II	112 Mmcf	.....	Under Constr	1959	.....	Hydrocarbon/ Lummus/	Hydrocarbon/ Lummus/
		Sulfur Recovery Phase II	970 tons	.....	Under Constr	.....	Parsons	Parsons/Heurtey Heurtey	Parsons/Heurtey Heurtey
		Sulfur Recovery Phase III	780 tons	$22,000,000	Engineering	1959	Parsons	Parsons & Heurtey	Parsons & Heurtey
		Sulfur Recovery Phase IV	1,000 tons	.....	Engineering	1961	Parsons	Parsons & Heurtey	Parsons & Heurtey
		Gas Plant Sections 4 & 5	.....	.....	Planning	.....	.....	Lummus	Lummus
		Ethylene	25,000 tons/yr	.....	Engineering	1960	.....	Hydrocarbon	Staff
EAST GERMANY									
Ministry of Coal & Energy	Rostock	Catalytic Oil Gasification	2.4 Mmcf	.....	Under Constr	.....	.....	Power Gas/ Didier	Power Gas/ Didier
	Stralsund	*Catalytic Oil Gasification	4.8 Mmcf	.....	Under Constr	.....	.....	Power-Gas Didier	Power-Gas Didier
WEST GERMANY									
B.P. Benzin und Petroleum	Dinslaken	*Distillation, Cat Reforming, Hydroforming, Copper Chloride	100,000 bbls	.....	Under Constr	1960	.....	Kellogg	.....
Buna Werke Huels	Marl, Kreis Recklinghausen	Synthetic Rubber	45,000 tons/yr	$37,000,000	Under Constr	.....	Esso; R & E Houdry; Firestone	Staff	Staff
Chemische Fabrik Holten	Lubwigshaven a Rein	Ethylene Oxide	9,000,000 lbs/yr	.....	Under Constr	.....	S D	S D	.....
Chemische Werke Hule	Marl	Polyethylene	6,000 tons/yr	.....	Planning	1959	Ziegler	Staff	Staff
Durag-Nerag	Misburg, Hannover	Platformer, Sulfur Recovery	4,500 bbls.	.....	Engineering	Sept 1960	UOP	Lurgi	Lurgi
		Delayed Coker	3,000 tons						
		Selective Cracker	21,000 bbls	.....	Under Constr	.....	.....	Lummus	Lummus
		Natural Gasoline							
Deutsche Shell	Harburg	Refinery with Crude Distiller Cat Reformer Hydrodesulfurization	40,000 bbls	.....	Under Constr	.....	.....	Lummus	.....
	Godorf	Refinery	30,000 bbls	.....	Under Constr	1960	.....	.....	.....
Erdolchemie	Niederrhein	Propylene Oxide	20,000 tons/yr	.....	Under Constr	1959	Farbenfabriken Bayer	Farbenfabriken Bayer	Farbenfabriken Bayer
		Ethylene	200,000 tons/yr	.....	Under Constr	End 1959	.....	S & W	S & W
		Ethanol	18,000 tons/yr	.....	Under Constr	End 1959	Shell	S & W	S & W
		Butadiene	30,000 tons/yr	.....	Engineering	Late 1960	.....	.....	.....
		Gasoline Selective Hydrogenation	90,000 tons/yr	.....	Under Constr	End 1959	BP	BP/Lurgi	Lurgi
Esso	Cologne	Butadiene	.....	.....	Complete	.....	Esso	Braun/Still	Braun/Still
		Ethylene	.....	.....	Complete	.....	Esso	Lurgi/GHH	Lurgi/GHH
		Propylene	.....	.....	Complete	.....	Esso	Kocks	Kocks
Esso	Hamburg-Harburg	*Absorber	9.1 Mmcf	$170,000	Complete	.....	Staff	Staff	Pintsch Bamag
		*Stripper	.....	.....	.....	.....	.....	.....	.....
Feldmuhle	Lulsdorf	Ethylene	40,000 tons/yr	.....	Engineering	.....	.....	Hydrocarbon Hydro M	Hydro M
Gewerkschaft Erdolraffinerie Emsland	Lingen Holthausen	Crude	32,000 bbls	.....	Under Constr	Early 1960	.....	Lurgi	Lurgi
		Unifiner-Platformer	4,700 bbls	.....	Planning	.....	UOP/ Shell	Lummus	Lummus
		Gas Oil De-Sulfuriser	5,500 bbls	.....	Planning	.....	UOP/ Shell	Lummus	Lummus
		Kerosine Desulfurization	270 tons	.....	Under Constr	Early 1960	.....	Lurgi	Lurgi
		Gasoline Desulfurization	207 tons	.....	Under Constr	Early 1960	.....	Lurgi	Lurgi

*First appearance in tabulation

Construction BOXSCORE Continued on Page 216

CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Frisia	Emden	Refinery	30,000 bbls	$17,000,000	Engineering	1959	.....	Parsons	Parsons
tali-Chemie	Bad Honningen	*Hydrogen	.....	.....	.....	1949	Hercules	Power-Gas	Power-Gas
Purfina Mineralolraffinerie	Duisburg	Topping, Platformer Hydrodesulfuriser	20,000 bbls	.....	Under Constr	Late 1959	UOP Shell	Lummus/Uhde	Lummus/Uhde
Rheinische Olefinwerke	Wesseling Bez. Koln	Polyethylene	.....	.....	Complete	.....	Phillips	Braun/Staff	.....
		Ethylene	.....	.....	Engineering	Jan. 1961	Kellogg	Braun/Lurgi	.....
Ruhrchemie	Oberhausen-Holten	Platformer	2,000 bbls	.....	Under Constr	Jan. 1960	UOP	Procon	Procon
		Unifiner	2,900 bbls	.....	Under Constr	Jan. 1960	UOP	Procon	Procon
Westdeutsch Erdolleitungs	Ruhlermoor	Crude Desalter	5,700 bbls	.....	Engineering	1959	Howe-Baker	Uhde	Dortmund
GREECE									
Greek Government	Ptolemaeus, Greece	Ammonia	300 tons	.....	Engineering	Mid 1962	Uhde, Casale	Uhde, Casale	Uhde, Casale
		Ammonium Sulfate	525 tons						
		Ammonium Nitrate	325 tons						
IRELAND									
Irish Refining	Whitegate	Refinery	23,000 bbls	$33,600,000	Approved	1959	.....	.....	.....
Esso Petr. (Ireland)			30,000 bbls	.....	Under Constr	1959	.....	.....	Lummus
Caltex (Ireland)									
Shell Mex., B. P.									
ITALY									
Anic	Cengio	Phthalic Anhydride	22,000,000 lbs/yr	.....	Under Constr	Early 1960	Badger Mfg	Badger Mfg	Badger Mfg
Azienda Colori Nazionali Affini									
Asfalti Bitumi Cementic Derivati, S.A.	Ragusa	Polyethylene	25 tons	.....	Under Constr	.....	.....	BASF	.....
Azienda Nazionale Idrogenazione Combustibil	Ravenna	Styrene Monomer	14,000 tons/yr	.....	Under Constr	.....	Koppers	SBA	SBA
		Butadiene	22,000 tons/yr	.....	Engineering	1959	Houdry	Catalytic	.....
		Ethylene	.....	.....	Under Constr	.....	Koppers	ANIC	.....
		*Acetylene, Butadiene, Synthetic Rubber	35,000 TPY	$55,000,000	Complete	.....	Union Carbide/ Phillips	B & R	B & R
Distilleria Italiana	Milan	Butanol	11,000 tons/yr	.....	Engineering	.....	Hoechst	Uhde	Uhde
Ftalital, S.p.a.	Italy	Maleic Anhydride	2,200,000 lb/yr	.....	Engineering	.....	S D	S D	.....
I.R.O.M.	Venice	Hydrofiner	6,500 bbls	.....	Complete	.....	.....	SNAM	SNAM
Italgas	Rome	*High-Btu Oil Gas	1.8 Mmcf	.....	Under Constr	1959	Semet Solvay	Power-Gas SAFII	Power-Gas SAFII
Mobil Oil Italiana	Naples	Cat Reforming	9,000 bbls	.....	Under Constr	.....	.....	CTIP	CTIP
		Cat Hydrodesulfurisation	10,000 bbls	.....	Under Constr	.....	.....	CTIP	CTIP
		Lube Exp.	.....	.....	Under Constr	.....	.....	Staff	Staff
		Exp. Polypropylene	.....	.....	Planning	1959	.....	.....	.....
Montecatini Societe Generale per l'Industria Mineraria Chimica	Ferrara	Exp. Formaldehyde	135,000,000 lbs/yr	$300,000	Under Constr	.....	.....	.....	.....
	Castellanza	Exp. Formaldehyde	700,000 tons/yr	$95,000,000	Under Constr	1962	.....	.....	.....
	Brindisi	Petrochemical							
Palermo Gas	Palermo	*Catalytic Oil Gasification	3.6 Mmcf	.....	Complete	.....	.....	Power-Gas	Power-Gas
Sincat	Priolio, Sicily	Ammonia	240 Metric Tons	.....	Under Constr	1959	Tex aco	Foster Wheeler	.....
		Ethylene	.....	.....	Engineering	1959	S & W	S & W	.....
		Treating	.....	.....	Engineering	1959	.....	S & W	.....
Snia Viscosa	Varedo, near Milan	Carbon Disulfide	.....	.....	Under Constr	1960	Food	.....	.....
Wtanic Petrolifera	Livorno	Naphtha Stabilizer and Splitter	11,000 bbls	$720,000	Engineering	Late 1959	.....	Esso	CTIP
Union Carbide	Sicily	Polyethylene	15,000 tons/yr	.....	Under Constr	1959	.....	.....	.....
Societa Edison S.A.	Celene	*Ethylene Oxide	26,500,000 lbs/yr	.....	Under Constr	1960	.....	.....	.....
NETHERLANDS									
B. F. Goodrich & Algemene	Arnheim	Butadiene	.....	.....	.....	1959	.....	.....	.....
		*Synthetic Rubber	.....	.....	Complete	.....	Goodrich	.....	.....
Kunstsijde Unie N.V.	.....	Styrene	.....	.....	.....	.....	.....	.....	.....
Esso Nederland	Rotterdam	Refinery	95,000 bbls	$50,000,000	Under Constr	Spring 1960	Esso	Esso	Badger N.V.
NORWAY									
Standard (N.J.)	Oslo Fjord	Refinery	40,000 bbls	$30,715,000	Engineering	Late 1960	Esso	Esso	Bechtel
PORTUGAL									
Ammoniaco Portugues	Esterreja.	Ammonium Sulfate	220 tons	.....	.....	.....	.....	.....	.....
Socedada Portuguesa de Petroquimica Sarl	Lisbon	Ammonia	185 tons	.....	Planning	.....	Uhde-Texaco	Uhde-STEC	Uhde-STEC
		Hydrogen	1.5 Mmcf	.....	.....	.....	.....	.....	.....
		Fuel Gas	11 Mmcf	.....	.....	.....	.....	.....	.....
RUMANIA									
Maschimport	.....	Formaldehyde	100 tons	.....	.....	.....	.....	Uhde	Uhde
Rummanian Govt.	Telesjen	Lube Oil	.....	.....	.....	.....	.....	.....	.....
		Natural Gas Treating	.....	.....	.....	.....	.....	.....	.....
	Borzesti	Petrochemical	.....	.....	.....	.....	.....	.....	.....
	Onesti	Synthetic Rubber	.....	.....	.....	.....	.....	.....	.....
SCOTLAND									
British Hydrocarbon Chemicals	Grangemouth	Polyethylene	25,000,000 lbs/yr	.....	Under Constr	1959	Phillips	S & W	S & W Ltd
		Ethylene	70,000 tons/yr	.....	Under Constr	Mid 1960	.....	S & W Ltd	S & W Ltd
		Cumene	.....	.....	Under Constr	Late 1959	Mid-Centry	S D S & W Ltd	S & W Ltd
		Phenol	.....	.....	Under Constr	Late 1959	Distillers	S & W Ltd	S & W Ltd
		Gasoline Treater	.....	.....	Under Constr	Early 1960	BP	Lummus	Lummus
British Petroleum	Grangemouth	*Copper Chloride, Kerosine Treating, De-ethaniser	2,000 bbls	.....	Complete	.....	.....	Power-Gas	Power-Gas
			2,000 bbls	.....	Complete	.....	.....	Power-Gas	Power-Gas
			625 bbls	.....	Complete	.....	.....	Power-Gas	Power-Gas
Union Carbide	Grangemouth	*Polyethylene	30,000,000 lbs/yr	.....	Under Constr	.....	.....	.....	.....
SOUTH AFRICA									
Phillips Petroleum-Industrial Development		*Carbon Black	22,000,000 lbs/yr	.....	Under Constr	.....	Staff	Staff	Staff
Standard Vacuum	Durban	*Exp. Asphalt Oxidizer	2,100 bbls	$415,000	Under Constr	1960	.....	Staff	.....
			600 bbls						
SPAIN									
Repesa	Cartegena	Two Stage Crude	35,000 bbls	.....	Engineering	Late 1959	.....	Foster Wheeler	Foster Wheeler
SWEDEN									
A. Johnson & Co.	Sweden	Refinery Exp.	.....	.....	Under Constr	.....	.....	Bechtel	Bechtel
Stockholm Gas & Water Works	Stockholm	Cat Oil Gasification	4 Mmcf	.....	Under Constr	1959	Power Gas	.....	Power Gas
SWITZERLAND									
Power-Gas	Winterthur	*Catalytic Oil Gasification	606,000 cu. ft.	.....	Under Constr	.....	.....	Power-Gas Didier	Power-Gas Didier
TURKEY									
Badische Anilin and Soda Fabrik	Kutahya	Ammonium Sulfate	60,000 tons/yr						
		Sulfuric, Nitric Acid	50,000 tons/yr	$20,000,000	Under Constr	.....	BASF	BASF	.....
Mobil Overseas, Shell, Caltex BP	Mersin	Refinery	65,000 bbls	$48,000,000	Under Constr	.....	.....	Foster Wheeler	Foster Wheeler

* First appearance in tabulation.

Construction BOXSCORE Continued on Page 219

1

No scraping, cleaning, resurfacing or replacing flanges when installing new seal!—

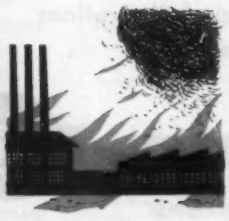
The unique design of Gask-O-Seals will save hundreds of man hours, and eliminate the tedious work of reconditioning flanges.

2

Save downtime—

Gask-O-Seals will not wear due to **pulse** or **vibration**. They last longer and are quickly and easily changed. **Sure, positive** sealing extends seal life. Fool proof installation reduces replacement time and repair.

3



Eliminate extreme hazard of "blow-out"—

Since Gask-O-Seals are **totally** confined with metal-to-metal contact of faying surfaces, the danger of a seal "blowing out" is completely eliminated under normal working conditions. This feature alone can save your company millions of dollars.

4

No retorquing of bolts necessary—

Once a Gask-O-Seal is installed there is no need to re-torque bolts. The seal can not "creep" or "cold flow." There is no need for tightening bolts to maximum, causing distortion of flanges. . . . . the flanges are easy to break loose at time of repair or overhaul.

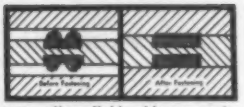
5

Re-useable—

Due to the carefully controlled mass-to-void ratio in the Gask-O-Seal design, the seal can not be over squeezed — its "memory" never destroyed by fastening pressures. They, therefore, may be reused several times with just ordinary care.

Plus — Due to low fastening torques required to effect a seal, flanges can be designed to greatly reduce mass and smaller bolts used, less bulky wrenches and tools are required and automatic equipment used for even faster installation. Gask-O-Seals will seal water, oil, air, hydraulic fluids, gases, gasoline and many other fluids; hi-vacuum to hi-pressure, in a very wide temperature range.

Try Gask-O-Seals and reduce your maintenance costs **now.**



Parker SEAL COMPANY

CULVER CITY, CALIFORNIA and CLEVELAND, OHIO

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For more data on advertised products, use Readers' Service Cards, last page.

New
CYCLO-TRELL
MECHANICAL
DUST COLLECTORS

These new Cyclo-trells can be built to fit any specific job. Available in Types C-10 (10″ diameter), C-24 (24″ diameter), IC (involute Cyclo-trell), ICL (involute Cyclo-trell, lined) and C-24-L (24″ lined). Also available: a new hopper discharge valve.

Write now for your copy of new Bulletin 300 which gives details and illustrations of the new Cyclo-trells and hopper discharge valve.

Research-Cottrell, Inc.

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Main Office and Plant: Bound Brook, New Jersey

REPRESENTATIVES IN PRINCIPAL CITIES OF U. S. AND CANADA

RC203

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Turkish Government..	Istanbul	Natural Gasoline	.....	.....	Planning	.....	.....	.....	.....
UNION OF SOUTH AFRICA									
YOUGOSLAVIA									
Yougoslav Government	Sisak	Topping and Cat Reforming	15,000 bbls	$5,400,000	Planning	1963	.....	Inst. Pet., Zagreb	Staff
		Ammonia	120/tons	$11,000,000	Planning	1962	Foster Wheeler	.....	.....

Near East

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
EGYPT									
Anglo-Egyptian Oilfields	Suez	Cat Reformer	2,300 bbls	.....	Projected	.....	.....	.....	.....
Egyptian Chem. Ind., KIMA S.A.E.	Aswan	Ammonia	315 tons	.....	Under Constr	1960	BASF	BASF	BASF
Egyptian Govt.....	Suez	Power	10,000 Kw	$2,200,000	Planned	1959	.....	.....	.....
		Atmos. Distl., Vac. Distl. & Lube Oils	20,000 bbls	$7,000,000	Planning	1960	.....	.....	.....
		Cat Reformer	3,000 bbls	$2,700,000	Planning	1962	.....	.....	.....
		Hydrodesulfuriser	2,700 bbls	$720,000	Planning	1962	.....	.....	.....
		Lube Oils	.....	$9,000,000	Planning	1963	.....	.....	.....
	Alexandria	Atmos. & Vac., Distl.	10,000 bbls	$1,400,000	Planning	.....	.....	.....	.....
	Cairo	Atmos. Distl. & Vac., Distl.	10,000 bbls	$1,400,000	Planning	.....	.....	.....	.....
IRAN									
Iran Government.....	.....	Nitrogen	30,000 tons/yr	$30,000,000	Planning	.....	Montecatini	.....	.....
IRAQ									
Iraq Government.....	Baghdad	Refinery Exp.	48,000 bbls	$11,000,000	Under Constr	1959	Esso	Foster Wheeler	Foster Wheeler
		Powerformer	5,000 bbls	.....	.....	1959	.....	Foster Wheeler	Foster Wheeler
		Kerosine Treating	5,000 bbls	.....	.....	1959	.....	Foster Wheeler	Foster Wheeler
		Synthesis Gas	121 tons	.....	Under Constr	.....	.....	Foster Wheeler	.....
	Qaiyarah	Refinery Revamp Crude Topping; Vacuum Distl.; Thermal Cracking Asphalt	7,500 bbls	.....	Planning	Late 1959	.....	.....	.....
ISRAEL									
Fertilizers & Chemicals	Haifa Bay	Ammonia Exp. Fertilizers	50 tons	$5,000,000	Under Constr	1959	.....	.....	.....
MALTA									
Malta Gas Board.....	Valetta	*Catalytic Oil Gasification	1 Mmcf	.....	Under Constr	1959	.....	Power-Gas	Power-Gas
PAKISTAN									
Pakistan Industrial Dev.	Fnchanj, Pakistan	Ammonia	225 tons	$20,000,000	Engineering	1961	Kobe Steel	Chemico	Chemico
		Urea	375 tons						
SAUDI ARABIA									
Arabian American Oil	Ras Tanura	Alkylation	1,210 bbls	$6,990,000	Under Constr	1959	Kellogg	Kellogg/Staff	Staff
		LPG	1,500 bbls	$1,025,000	Engineering	1961	Kellogg	Staff	Staff
SYRIA									
Syrian Government...	Homs	Refinery	20,000 bbls	$14,000,000	Planning	1959	Technoexport Prague	Technoexport Prague	Technoexport Prague

Far East

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
HONG KONG									
Hong Kong & China Gas	Hong Kong	Cat Oil Gasification	1.5 Mmcf	.....	Under Constr	1959	Hercules	Power Gas	Power Gas
INDIA									
Alkali & Chemical of India	India	Polyethylene	.....	$6,300,000	Complete	.....	I C I	.....	Simon-Carves
Indian Government...	Assam	Refinery	15,000 bbls	$17,000,000	Planning	.....	.....	Rumanian Government	Rumanian Government
National Carbon.....	Bombay	*Polyethylene	.....	.....	Under Constr	Mid 1960	.....	B & R	B & R
Sahu Chemicals.....	Varanasi	Ammonium Chloride	120 tons	.....	Under Constr	1959	Uhde	Uhde	Uhde
		Soda Ash Fertiliser	120 tons	.....	Under Constr	1959	Pintsch/Bamag	Pintsch/Bamag	Pintsch/Bamag
		Ammonia	120 tons	.....	Under Constr	1959	John Thompson	CECIP	John Thompson
Standard Vacuum....	Bombay	Asphalt	125,000 tons/yr	$3,500,000	Under Constr	1959	.....	Parsons	Parsons
INDONESIA									
Indonesian Government.....	Palembaug, Sumatra	Urea Fertiliser	330 tons	.....	Under Constr	.....	.....	Foster Wheeler	Foster Wheeler
JAPAN									
Asahi-Dow.....	Kawasaki	Styrene Monomer	50 Metric tons	$4,150,000	Under Constr	Dec., 1959	Dow	Dow	Dow
Asahi Chemical..... Industries	Nobeoka	NH, Synthesis Gas	50 Metric Tons	$3,670,000	Under Constr	Nov 1959	Texaco/ Chemico	Chemico	Chemico
Daikyo Oil.....	Yokkaichi	Topping & Vacuum	30,000 bbls	.....	Under Constr	1959	.....	J G C	J G C
Furukawa Chemical Industries	Japan	Polyethylene	.....	.....	Under Constr	1959	Standard (Ind.)	.....	.....
		Platforming	5,000 bbls	.....	Planning	Mid 1960	UOP	UOP/JGC	.....
Japan Synthetic Rubber	Yokkaichi	Butadiene & GR-S Rubber	45,000 tons/yr	$30,000,000	Under Constr	1959	Houdry Esso Goodyear	Blaw-Knox; Catalytic; Chiyoda	Chiyoda
Koa Oil.....	Iwakuni	F C C	5,500 bbls	.....	Under Constr	Early 1960	UOP	UOP/JGC	.....
		Delayed Coker (Thermal Cracker Revamp)	4,500 bbls	.....	Planning	1960	UOP	UOP/JGC	.....
		Vacuum Distl.	8,400 bbls	.....	Under Constr	Nov 1959	UOP	JGC	.....
Kyowa Fermentation Industry Co., Ltd.	.....	Acetaldehyde	45 tons	.....	Planning	.....	Knapsack-Grieshem	Uhde	Uhde
	Ube	*Butanol, Octanol, Acetylene, Ethylene	.....	$13,500,000 $6,500,000	Planning Planning	.....	.....	Ilon-Tears	Ilon-Tears

* First appearance in tabulation

Construction BOXSCORE Continued on Page 220

CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Marusen Oil	Matsuyama	Udex	1,500 bbls	$2,200,000	Under Constr		UOP	UOP; J G C	J G C
		Benzene	6,500 tons/yr				UOP		
		Toluene	4,000 tons/yr				UOP		
		Xylene	4,000 tons/yr				UOP		
		Oxidation	20 tons	$4,000,000	Engineering		S D	S D	S D
		Benzoic Acid	900 tons/yr			April 1960	S D		
		Phthalic Acid Anhydride	2,245 tons/yr			April 1960	S D		
		Isophthalic Acid	5,600 tons/yr			April 1960	S D		
		Terephthalic Acid	2,500 tons/yr			April 1960	S D		
		Crude Topping	25,000 bbls	$1,400,000	Under Constr	1959		Chiyoda	Chiyoda
Mitsui Petrochemical Industries	Iwakuni City	Terephthalic Acid			Under Constr	1959	S D	S D	Mitsui Shipbuilding
		Paraxylene			Engineering	1959	S D	S D	
		Cat Reformer			Licensed				
		Paraxylene				1959		S D	
Mitsubishi Petrochemical	Yokkaichi	Ethylene Oxide	15.4 tons		Complete		S D	S D; Chiyoda	Chiyoda
		Ethylene Glycol	9.2 tons	$28,000,000	Complete		S D	S D; Chiyoda	Chiyoda
		Ethylene	76.7 tons		Complete		S & W	S & W/JGC	JGC/Staff
		Polyethylene	30.8 tons		Complete		BASF	JGC/Staff	Mitsubishi Shipbuilding & Eng./Mitsubishi Chemical Engrg
Nippon Petrochemicals	Kawasaki	Ethylene	25,000 tons/yr	$16,000,000	Engineering	1959	S&W Esso	S&W; J G C	S&W; J G C
		Butadiene	5,000 tons/yr						
Nitto Chemical Industry		*Synthesis Gas	125 tons	$6,000,000	Planning		Texaco	Iino-Tears	Iino-Tears
SBA & Sumitomo Chemical	Niihama City	Acetylene-Ethylene			Planning			Staff	Staff
Showa Denko KK	Tokyo	Synthesis Gas	121 short tons		Under Constr	1959	Texaco	Foster Wheeler	Foster Wheeler
			121 short tons		Under Constr	1959	Texaco	Foster Wheeler	
Showa Yuka	Japan	Polyethylene			Complete		Phillips	Staff/Braun	
Toa Nenryo Kogyo	Shimizu	Exp. Powerformer; Hydrofiner; Kerosine Acid treating; Copper Sweetener; Offsite Facilities	43,500 bbls	$12,500,000	Under Constr				
Ube Kosan		Ammonia	100 tons/day		Engineering	Jan. 1960		Chemico	Chemico
KOREA									
Korean Government	Chung-ju	Urea	270 tons	$33,500,000	Under Constr		Inventa-Vulcan	Hydrocarbon, McGraw Vulcan	Hydrocarbon McGraw
	Naju	Urea	95,000 tons/yr		Engineering	1962	Inventa	Lurgi, et al	Lurgi, et al
TAIWAN									
Thai Defense Ministry	Bangkok	Refinery	5,000 bbls	$30,000,000				Japanese Fuji	Japanese Fuji

Australasia

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
AUSTRALIA									
Australian Oil Refining	Kurnell	*Epx. Refinery:				1961	UOP/ Kellogg	Kellogg	
		*Crude	45,000 bbls						
		*FCCU	18,000 bbls						
		*Alkylation	3,400 bbls						
Bitumen & Oil Refineries	Sydney	Diesel Unifiner	2,500 bbls		Under Constr			UOP	Staff
		Crude	12,000 bbls		Proposed			Procon	Procon
Imperial Chemical Industries of Australia & New Zealand	Australia	Polyethylene	5,000 tons/yr	$5,040,000	Under Constr				
Shell Oil	Newport	Oil Blending							
Shell Refining (Australia)	Clyde	Platformer	6,700 bbls		Under Constr		UOP		Procon
	Geelong	Hydrodesulfuriser	11,000 bbls		Projected	1959			
Standard Vacuum	Melbourne	Refinery Revamp			Complete			Fluor	Fluor
	Adelaide	Refinery	30,000 bbls	$30,000,000	Planning				
	Altona	*Petrochemicals (Ethylene & Butadiene)	20,000 tons/yr	$28,000,000	Engineering	Winter 1961		Fluor	Utah-Australia
Shell Chemical	Clyde	Resins, Alkylates		$22,000,000	Planning				
PHILIPPINE ISLANDS									
Gulf Oil	Luzon	Refinery	20,000 bbls	$23,000,000	Planning	Late 1960			
Shell (Philippines)	Manila	Refinery			Negotiating				
Standard Vacuum	Bataan	Refinery	25,250 bbls	$35,000,000	Engineering	Late 1960		Foster Wheeler	Foster Wheeler
Union Carbide	Melbourne	Polyethylene	15,000,000 lbs/yr		Planned	1961			

* First appearance in tabulation.

Atlantic—Atlantic Ref. Co.
Austin—The Austin Co.
Badger France—Badger Ltd.
Badger N. V.—Badger N. V., Netherlands
Badger Mfg.—Badger Mfg. Co.
B & R—Brown & Root, Inc.
BASF—Badische Anilin & Sod. Fab.
Bechtel—Bechtel Corp.
Blaw-Knox—Blaw-Knox Co.
Braun—C F Braun Co.
Braziliera
Calif. Res.—California Research Corp.
Canadian
Canadian Badger
Canadian Bechtel
Catalytic—Catalytic Construction Co.
Chemical Projects Assoc.
Chemico—Chemical Construction Co.
CTIP—Compagnia Technica Industria Petroli
Davis Construction
Day & Zimmerman
Devon Palmer
Dortmund
Dresser—Dresser Engineering Corp.
Ehrhart—Ehrhart & Associates, Inc.
Esso—Esso Research and Engineering Co.
Ferguson—H. K. Ferguson Co.
Fijinagata Shipyard
Fisher
Fluor—Fluor Corp.
Food—Food Machinery & Chem. Corp.
Foster Wheeler—Foster Wheeler Corp.
GHH
Girdler—Girdler Construction Division, Chemetron Corp.
Hawaiian Dredging
Heurtey
Hudson—Hudson Engineering Corp.
Hughes
Hydrocarbon—Hydrocarbon Research, Inc.
HWP—Head Wrightson Process, Ltd.
Inst. Pet., Zagreb
Japanese Fuji
JGC—Japan Gasoline Co.
Kaigho
Kellogg—The M. W. Kellogg Co.
Kidde Constr.—Walter Kidde Constructors, Inc.
Kidde Engrs.—Walter Kidde Engineers Southwest, Inc.
Kobe Steel
Kocks Still
Koppers—Koppers Co., Inc.
Leonard—Leonard Construction Co.
Litwin—Litwin Engineering Co.
Lummus—The Lummus Co.
Lurgi—Lurgi G. m. b. H.
Macco—Macco Corp.
McAlpine-Wimpey
McKee—Arthur G. McKee Co.
Mitsui Shipbuilding
Montreal, SA
Nofsinger—The C. W. Nofsinger Co.
Olsen—O. L. Olsen Co.
Parsons—The Ralph M. Parsons Co.
Pintsch Bamag
Poole
Power Gas—Power Gas Corp., Ltd.
Pritchard—J. F. Pritchard Co.
Process Contracting
Procon—Procon, Inc.
Quaker—Quaker Valley Constructors
R & E
S&W—Stone & Webster Engineering Corp., Chemical Division
S&W Ltd.—Stone & Webster Canada, Ltd.
SBA—Soc. Belge de L'Azote et des Produits Chimiques du Marly
SD—Scientific Design
SETAL
SFST—Societe Francais des Services Techniques
SNAM
Simon—Carves, Ltd.
Soc. Chemique—Societe Chimique de la Grande Paroisse
Stamicarbon
Stearns-Roger—Stearns-Roger Mfg. Co.
STEC
Sumner Sollitt—Sumner Sollit Co.
Swco—Southwestern Engineering Co.
Technoexport, Prague
Tolleson—Tolleson Petro-Chem Constructors
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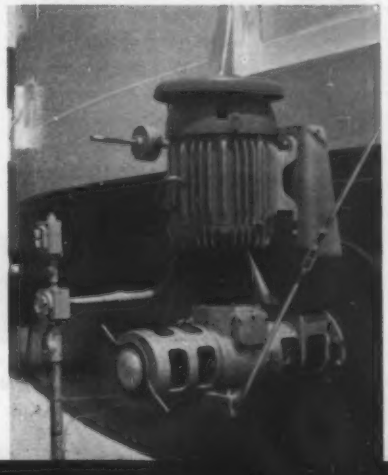

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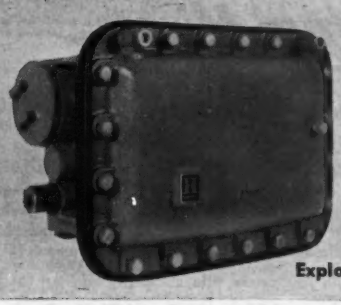

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Just two wires connect field-mounted units of the new *ElectriK Tel-O-Set* to your control room. These wires carry both signal and power. No line power connections in the field—only in the control room.

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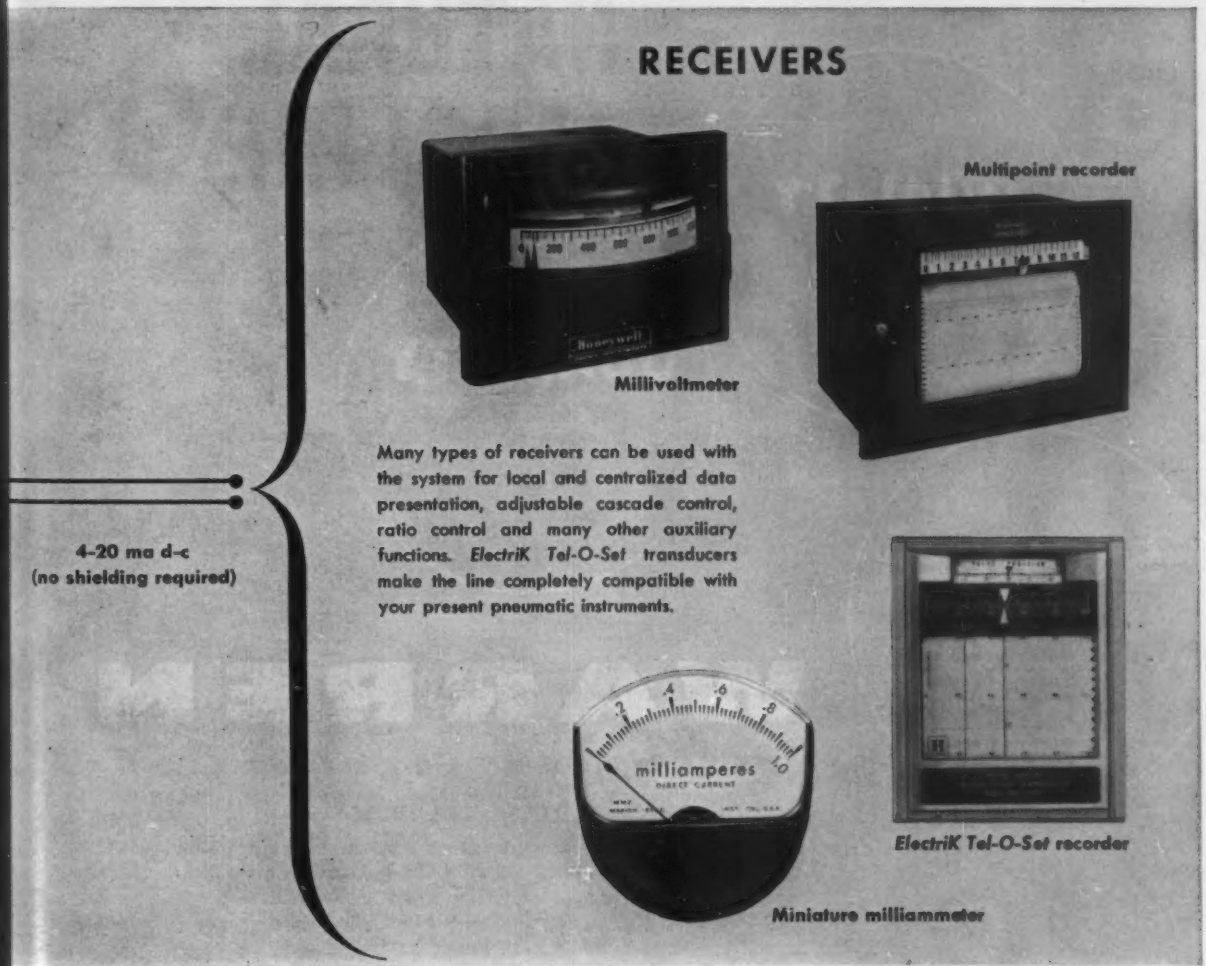
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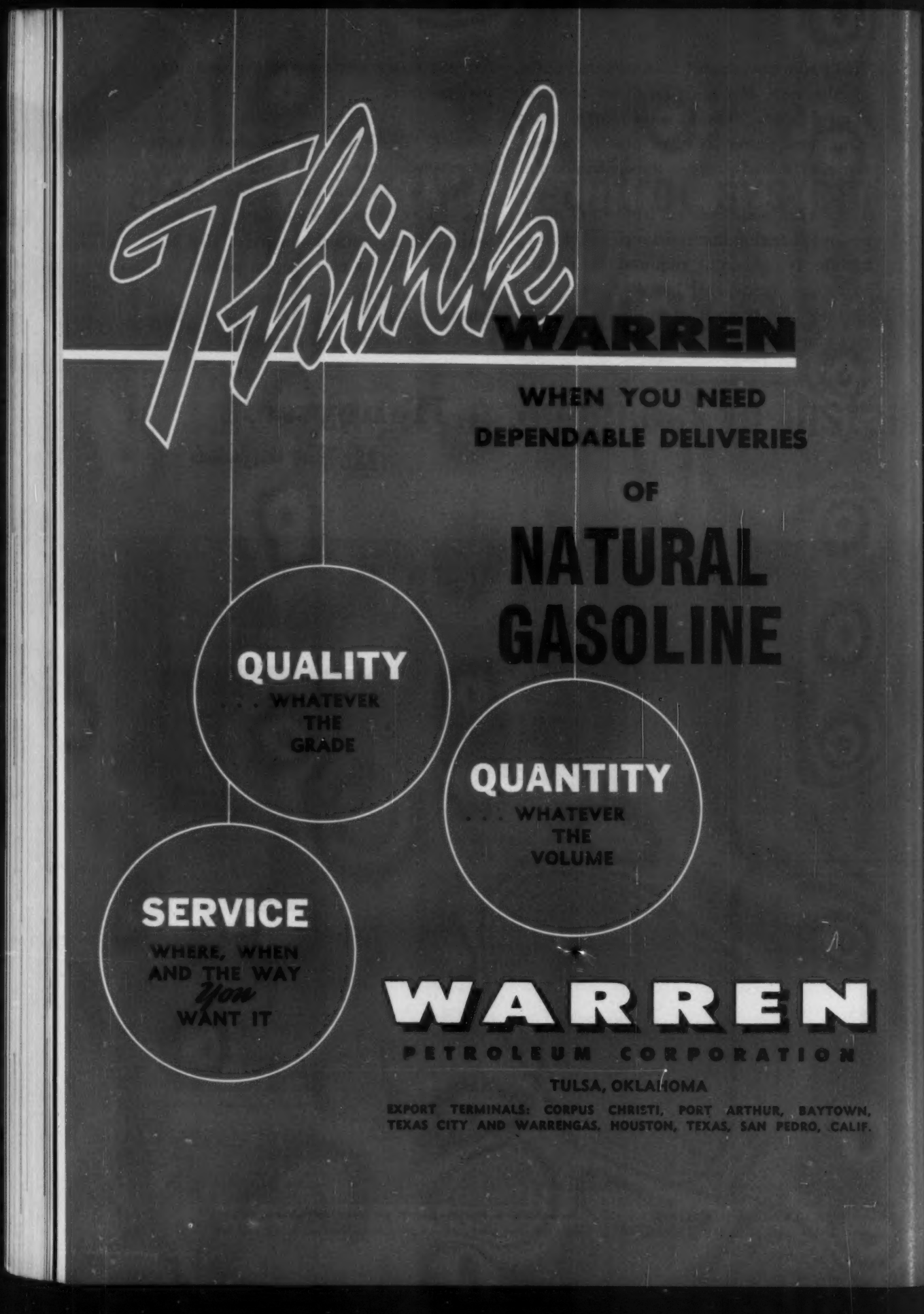
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Called upon for an impromptu speech would you "er" and "ah" and thoroughly embarrass yourself and your audience? Here's a formula that will help you out in such a situation, plus tips on introducing and "thanking" a speaker

Three Hard Speeches to Make

George McWilliam
British Columbia Railway Electric Co., Ltd., Victoria, B. C.

THERE'S LITTLE doubt that one of the hardest speeches to make is the impromptu speech where you have very little or no time to prepare exactly what you want to say. Two other kinds of talks which can give you some difficulty unless handled just right are the one you give to introduce another speaker and your comments following his address. However, there are certain rules you can follow which will make all three much easier for you. But let's take them one at a time!

THE IMPROMPTU SPEECH

An impromptu talk is a speech that you may be called upon to deliver entirely without notice to an expectant audience. To the novice this could be a terrifying experience and this type of situation probably more than any other, has persuaded people to study public speaking. The favorite theme in some magazine advertisements for teaching public speaking by correspondence has been, "The president asked me to speak at the sales convention and three months later I was sales manager." However, joking aside, a well made, thoughtful impromptu talk has undoubtedly been the turning point in many careers.

At the outset, let us say there is nothing to be afraid of. We will take for granted that you know the subject of your speech. You know something of it or otherwise you would not have been asked to speak in the first place. However, you have been asked—now, how are you going to do it?

Your Big Chance. The big secret of this type of speech is simple organization. Whoever has asked you to speak knows you have some particular knowledge of the subject. Another point in your favor is that your audience knows you are on the spot and is sympathetic. The most important thing now is what impression are you going to give them as you rise to your feet. Are you going to, "er" and "ah"? Will you apologize—say that on this short notice—stall and confound the friendly confidence of your audience at the outset? If you are, opportunity has pounded on your front door and pitched a tent, but your answer has been a rebuff. No you can't do that!

You should smilingly address the chair, and your audience quietly. Pause to allow your audience to relax, then start off with a standard introduction. You must give an impression of poise, sincerity, and possibly specialized information.

Now, as to the technique peculiar to the impromptu speech. The average audience believes it to be difficult but with your knowledge of public speaking you know it isn't.

Use This Formula. The easy formula that has been a key factor in

the speeches of nine-tenths of the impromptu speeches ever made, is contained in the following seven words:

1. What
2. Where
3. How
4. Why
5. When
6. Who
7. Which

Your thoughts and knowledge can be compared to a flowing stream containing thousands of units of useful but unharnessed energy. These words can be compared with power stations that transform your knowledge into power to perform useful work and provoke action.

They are questions you ask yourself about the subject although not necessarily in the order named.

For instance if the subject was unemployment:

HOW has employment been handled in this country?

WHAT governments have handled it?

WHAT has it cost?

WHERE has unemployment been concentrated?

WHERE has trouble developed?

WHY has trouble developed?

WHO have been unemployed—young or old—male or female?

WHEN did it start?

WHEN will it end?

HOW can it be ended in your opinion?

WHICH is the best method of handling it?

Study Others. You can see from the formula using those seven words that it is very easy to develop a talk on very short notice. You will find in your impromptu speeches, you will benefit from carefully studying other speakers. Little tricks that they have used, and that you have unconsciously observed, will come to mind and assist you in the construction of the speech.

Some speakers frequently called on for impromptu speeches have a store of anecdotes or quotations suitable for almost all occasions: "Ladies and gentlemen the prime consideration at this moment is brevity—my remarks therefore will be like a modern feminine costume—long enough to cover and short enough to be interesting." However, while such tricks are not essential, they have their value.

The essentials are contained in the formula given above. Do not drag out your speech. Have thought provoking introduction and directly you have said what you have to say put a punch into your conclusion and sit down.

It is well to remember that an impromptu speech is an opportunity. Accept it. Take it seriously. It's quite simple.

THE SPEECH OF INTRODUCTION

In introducing a speaker yours is a two-fold task. First, you must make your speaker, your guest of honor, feel at home. Secondly, you must introduce him, efficiently and graciously, to your meeting.

In making this introduction your prime consideration is brevity. The situation, embarrassing and annoying to both speaker and audience wherein the chairman makes an address of some length introducing a speaker, is a landmark of humor. However, it definitely is not humorous. I can recall several cases where a chairman has taken over thirty minutes to introduce a speaker.

Rule One—Be Brief. In preparing a speech of introduction, and a speech of introduction must be prepared just as any other speech, there are two angles to consider:

1. The material for your speech.
2. Your manner of delivery.

Let's take these one at a time. The material for your speech of introduction should include:

1. What is the subject?
2. Why is the subject?
3. Who is the speaker (not necessarily his name, but what he is)?
4. Why is he the speaker?
5. Appreciation of courtesy of the speaker.
6. Welcome and formal introduction.

The above could be a formula for a "safe" introduction—brief, thoughtful and gracious. Here's how it works in actual practice.

Your job is to secure the attention of the audience for your guest and naturally you have prepared for the task. You possibly have telephoned his secretary for certain information asking her if there is any particular angle that should be stressed. You may have contacted him directly. If he is a well known person, you have possibly contacted the better known sources such as your public library.

One Example. Let us use the formula and develop a short introduction:

1. **What is the subject.** "Today we are to be favored with an address on unemployment."

2. **Why the subject?** This is without doubt one of the outstanding problems of our country. You will hear it discussed North and South and East and West—in high places and in low. It is the subject of gossip and deep concern. We all have our pet solutions for the problem. You all have come in personal contact with it and it must affect directly and indirectly the livelihood and future of every one of you."

3. **Who is the speaker?** "If anyone can be called an expert and authority on unemployment, our guest today must certainly be placed in that category. For years Secretary of Labor, he has come in contact with almost every phase of the problem. Since his college days when he worked his way through Yale University, he has seen this problem grow in national significance."

4. **Why the speaker?** "His studies and experiments in the field of unemployment have been watched with close interest across the entire United States."

5. **Appreciation.** I know that his courtesy in honoring our table today is appreciated by you all.

6. (Formal Introduction) "Gentlemen—the Honorable....., secretary of labor, who will address you on the subject of unemployment—Mr.....

The above is only one application of the formula. There are many, many varieties of application.

Be Careful. One warning, in preparing your material, be sure that it is accurate. If you are not sure of its accuracy, throw it out. Never take a chance if you want to avoid embarrasing yourself and your meeting.

One more warning—this may seem absurd to you, but be sure to get the name of the speaker correctly, and its correct pronunciation. This situation is not so extreme as you may surmise—it does develop quite occasionally and because of the regularity of its development it also is firmly ensconced in the field of humor. You have probably heard before of the chairman heaping praise on praise—"he needs no introduction, Mr. er . . ah . . . er." Therefore:

Print his name somewhere where you can see it plainly from your standing position when making the introduction.

The speech of introduction is a prepared speech. The ordinary rules of speech construction apply. The speech has an introduction, body and ending. As you grow in experience you will introduce your speech of introduction with an anecdote or a humorous note. You will refer to previous associations with the speaker and so on. However, until you have more experience play it safe. Stick to the formula. Your job is not to impress your audience with your wit—it is to introduce the speaker.

What Manner? As far as manner is concerned this is most important. A chairman, ill at ease (possibly because he has not prepared his introduction) will make his audience restless and will handicap the speaker before he commences. Relax—smile. Genial and urbane is the ideal chairman. Your speech of introduction is not a declamation but delivered if possible in the conversational style.

Your job once again is to create a receptive atmosphere and make your guest feel at home.

An important part of your speech is the indication or the cue you give your guest that he now has the floor. Just before finally using his name, turn to the guest speaker and with a slight bow and possibly a gesture—invite him to his feet.

Remain standing until your guest commences to rise.

THE "THANK YOU" SPEECH

Over a period of time you have all heard speeches of "Thank You." You will all agree that a brief, gracious speech of "Thank You" can add considerable to your program.

Let's briefly delve into the mechanics of it.

Unless this is a response to a toast, this is always an impromptu speech and you have rules for impromptu speeches in this article. One thing that must be remembered is that you are responding on behalf of the meeting and you should indicate this in your remarks quite plainly. Often the speaker is addressed direct.

Please Be Brief. All that is really required is tact and courtesy. Brevity again is the first criterion. I am often reminded of the old saying "Take the bull by the horns." In the case of thanking a speaker I suggest you take "the bull by the tail." You can let go just that much sooner.

If there is such a thing as a formula for a speech of Thank You it most certainly should include the following:

1. A reference to the chairman's introduction.

2. A reference to a highlight of the speech.

3. Thanks for his courtesy in attending.

4. If he calls for action assure him that his representations will receive consideration.

Here is a sample of a short "Thank You Speech."

"Mr. Chairman, Mr....., Gentlemen. It has fallen to my privilege to express on your behalf, our sincere appreciation of Mr.....'s address. We have keenly anticipated this talk because there is not one of us that is not familiar in some way with the very fine work in the field of unemployment research of our honored guest. In his address today he has opened new vistas of thought for us.

"His figures on the problem have astounded all of us, and I know that I can assure him on your behalf that his suggestions will receive serious and immediate attention.

"Mr....., the applause of this meeting has indicated to you in a small measure our appreciation of your most thoughtful address and too—of your courtesy in visiting us. It is all too seldom we have the opportunity of listening to so thoroughly informative an address.

"Thank you, Sir, and may we extend to you our best wishes for your continued success in your work on this problem—Unemployment."

Keep It Simple. Once again—you are still a novice. You are not unique in this category as 75 percent of our speakers are in that same classification. However, your audience need not know this and they won't know it as long as you do not attempt to over-elaborate your speech. Make it *simple, brief* and *courteous.*

A simple, brief speech will be appreciated by the speaker and will adequately express the thanks of the other listeners to the address.

Alternatively, an over-elaborate speech will stamp you for what you are and will be the reverse of your object—to thank the speaker for his address.

There are probably very few better ways of developing executive qualities in employes than through public speaking. Although all can't be leaders, public speaking aids in developing confidence and poise which sometimes is so necessary for promotion. ##

About the Author

George McWilliam attended the University of British Columbia. He later studied engine mechanics, and taught an Aero-Engine Course for the Royal Canadian Air Force, for which he also wrote a syliabus. He then joined British Columbia Electric Co. and was appointed personnel assistant. In this capacity he handled employment, interviewing, employe counselling, administration of psychological tests and their interpretation, employe training, and organization of technical and clerical courses. He has taught and organized courses in public speaking and first aid. For the past eight years, McWilliams has been in charge of industrial safety for B.C. Electric.

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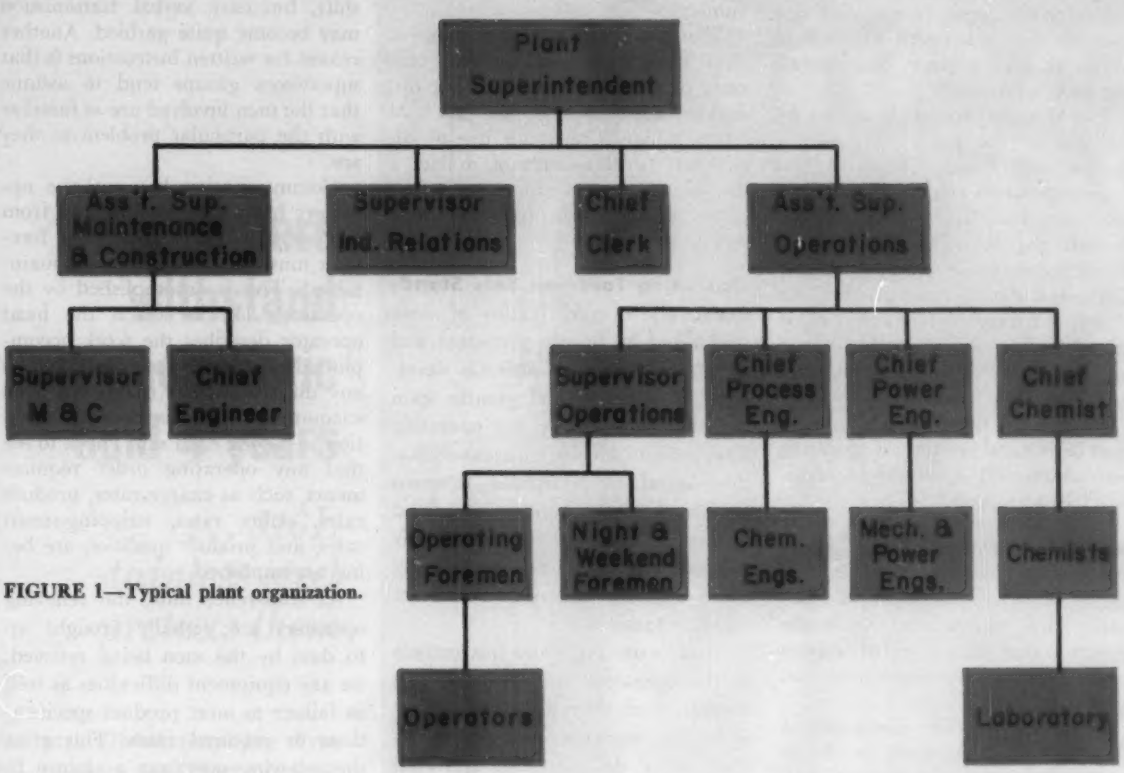

FIGURE 1—Typical plant organization.

Standard Procedures Aren't Enough

During startups, shutdowns and emergencies, standard procedures are necessary. But in learning daily safe and economical operations, planned procedures and operating manuals aren't the whole answer.

James R. Howard
Texaco, Inc.
Westville, N. J.

STANDARD PROCEDURES are absolutely necessary to crystallize our thinking on startups, shutdowns, and emergencies. We contend, however, that they are by no means the whole answer. Have you ever read such procedures? They are usually in outline form, quite long, and extremely dry reading. Many an operator has drifted off into day dreams before completing the second page.

The great majority of the operator's time is spent in activities other than those previously mentioned—namely, normal operations. If we assign approximately four weeks a year to inspection and test and one week to startups and shutdowns, this leaves 47 weeks of so-called normal operations.

Of course, we attempt to minimize emergency type operations, and will assume here that they are eliminated by the foresight of our unit operators, operating supervisors, and technical people. Thus, 47 out of the 48 available weeks of operations, or 98 percent of the time, the procedures used are something other than startup, shutdown, or emergency.

The Problem. Our objective is to develop an organization and techniques to assure that each individual operating unit obtains smooth on-test results at the desired throughput and in an economical manner. This sounds simple, but becomes rather complicated when we consider the details of coordinating the operations of the individual components of a modern unit.

To handle the mechanical operations of the unit satisfactorily, the operating supervisors and operators must know the equipment and its operating characteristics thoroughly

in order to devise means to get along at times without portions of it. To gain this knowledge requires almost continuous training, review, and mutual discussions between the various technical, maintenance, and operating people involved.

The days of operating a unit by the seat of the pants have almost disappeared. Possibly some of you remember when control instruments were very few, but you did have a pressure gage at a strategic location. When the pressure got above a certain point, the operator grabbed the "fraidy-cat rope" as he made a rapid exit. This opened the relief valves and, we hoped, would shut the unit down before it exploded.

We believe that an environment must be created around an operating unit which will minimize or eliminate bad operation.

Team Effort Essential. Fig. 1 will give you an idea of one of Texaco's typical plant organizations. We primarily are concerned with the branch from the superintendent through the assistant superintendent, operations.

As in many other endeavors, a team effort is required to obtain good results on a modern unit. This involves safety people, engineers, chemists, supervisors, and operators.

Our lineup may be compared to a football team, as shown in Fig. 2. The various technical people concerned with operations and maintenance, as well as the safety people, make up the line. The operating foreman is the quarterback while the remaining members of the backfield are the operators. They are the boys who carry the ball, and the way is cleared by the members of the line.

The coach who calls the plays is the assistant superintendent of operations aided by the supervisor of operations. The athletic director is, of course, the superintendent. On this team, talking in the huddle is encouraged because this assists our use of the right play at the right time.

Our opponents are rather "shifty" and constantly present. They may be mechanical, but are more likely to be personnel failures such as lack of experience, incomplete knowledge, or lack of alertness. Our job is to minimize our weaknesses and maximize our strengths. If we successfully do this, we will score at will and consistently throw the opponents for a loss when they attempt to carry the ball—most of the time making them fumble.

This is a peculiar kind of game in that time outs are allowed only once or twice per year and our operators must be "on the ball" 24 hours a day. Otherwise the penalties can be thousands of dollars a day because of poor play or even no game at all, as in the case of a serious mishap.

Operating Foreman Sets Standards. The over-all quality of work performed by hourly personnel and the safety-conscious attitude developed by them depend greatly upon the standards set by the operating foreman and his daily insistance that these standards be upheld. It seems evident that an organization trained to obtain good results on daily routines will handle major operating changes and emergencies in an acceptable fashion.

Clear, concise daily instructions to the operators are essential. The mechanics of their preparation start with the supervisor of operations who issues daily written general orders which cover desired unit charge rates, cut points, destination of products, product qualities, and blends. If there are any changes from the previous day's operations, the operating foreman will outline, in his order book located at the unit, the manner and timing which he wants used.

In addition, the operating foreman covers in his order book any special work, such as equipment repairs, precautionary measures, or special check procedures for each of the shifts. The head operator on the shift signs his initials at the bottom of these orders to indicate he has read and understood them. In this way the operating foreman has records to show his orders have been read and presumably understood.

No Communications Breakdown. We wish to stress that the written daily instructions should be complete, concise, and clear. They should cover why the job must be done, the procedures to follow, safety precautions, use of permits, and the time for completion of the job. Such instructions are much better than verbal requests passed from shift to shift, because verbal transmission may become quite garbled. Another reason for written instructions is that supervisory groups tend to assume that the men involved are as familiar with the particular problem as they are.

Communication between the operators from shift to shift and from the operators to the operating foreman must be established and maintained. This is accomplished by the operator's log in which the head operator describes the work accomplished on his shift and summarizes any difficulties that may have been encountered. This is done in addition to having each shift check to see that any operating order requirements, such as charge rates, product rates, reflux rates, stripping-steam rates, and product qualities, are being accomplished.

At shift-relief time, the relieving operators are verbally brought up to date by the men being relieved, on any equipment difficulties as well as failure to meet product specifications or required rates. This gives the relieving operators a chance to ask questions even though this same information is briefly covered in the records.

Other records kept by the operators include still sheets, tank-gage books, and equipment books in which such items as leaking valves or special equipment checks are recorded. By these means continuity of operations (including unusual conditions) from shift to shift is maintained.

Extra Dividends. Each morning the foreman checks the operators' records and is thus in a position to further investigate, or take immediate action on, any difficulties or failure to follow instructions. Not to be overlooked are the dividends realized from our foremen and technical people showing active interest and appreciation for a job well-done by the hourly operators in an emergency or planned change.

One of our operating foremen stated that a little barnyard psychology sprinkled sparingly over the seeds of good operating procedures

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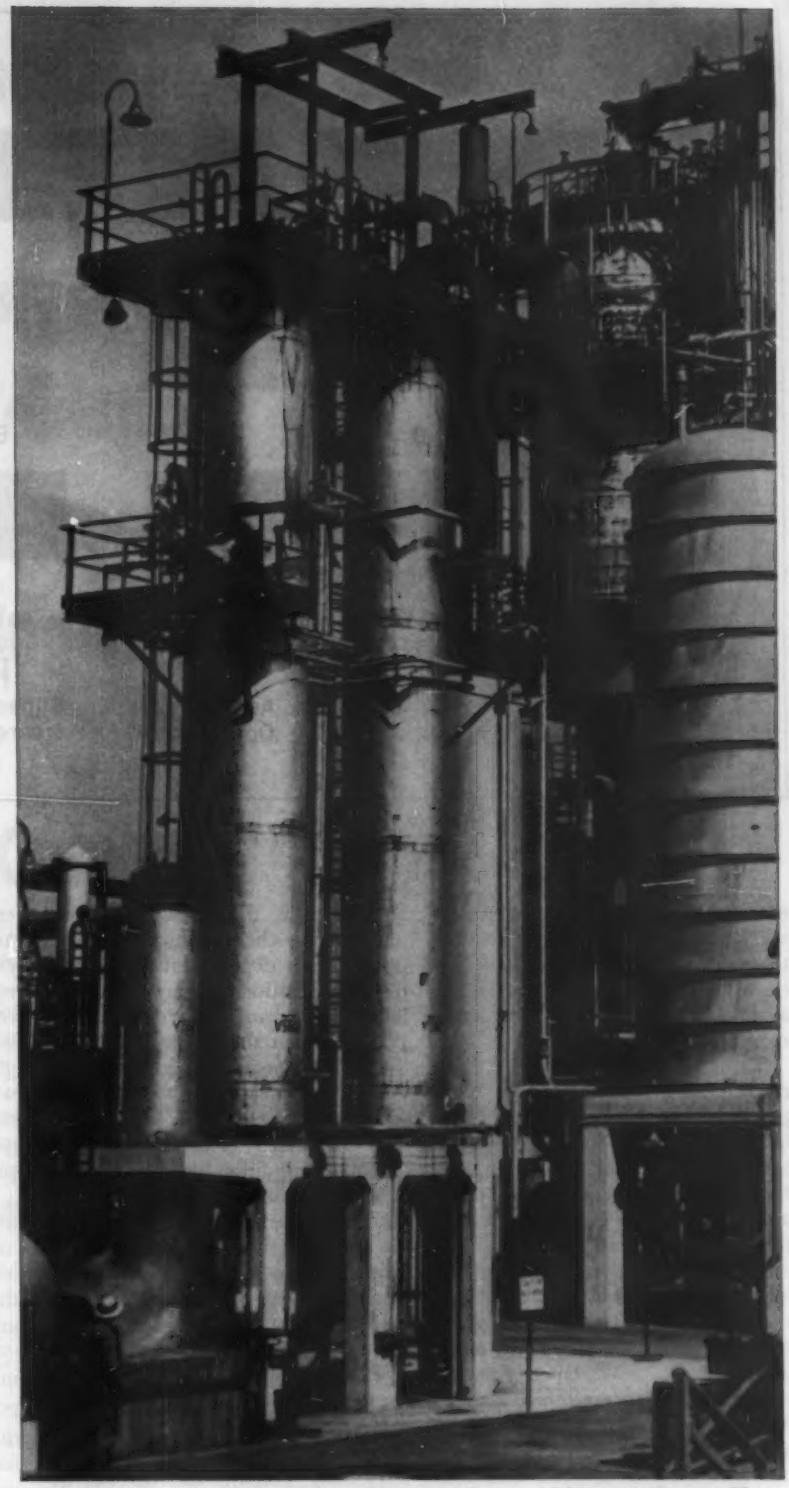

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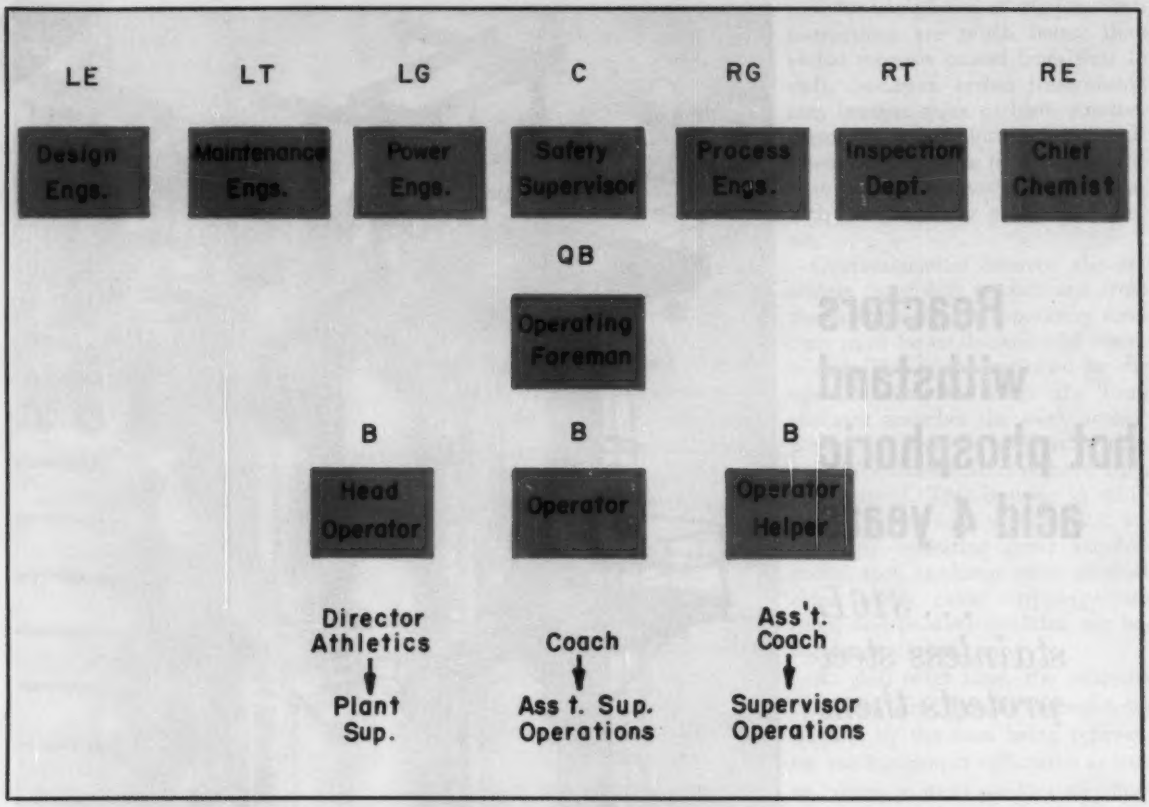

FIGURE 2—Plant operations team.

makes them sprout with surprising vigor. His complimentary remarks to an operator on a job well-done have been looked upon suspiciously at times but he has never yet been requested to cease.

The operating foremen have the responsibility of making certain that proper safety precautions are taken before any piece of equipment is turned over to the maintenance forces for repairs. The foreman or his assistant must countersign permits for unheading, entry, hot work, or concrete breaking after such permits have been prepared and signed by the operator. These are permits covering items such as steaming, blinding, gas tests, type of work, restrictions, and time limits. Experienced checking and follow-up on safe working conditions for the maintenance people is thus obtained.

Function of Technical Forces. In normal day-to-day operations our technical forces act in an advisory capacity to the operators, foremen, or supervisor of operations, under the direction of plant management. For instance, the units are checked each day by chemical engineers from the process department who make recommendations on any changes in operations that appear desirable. Test runs on the whole unit or on individual pieces of equipment are made periodically and analyzed to devise improvements in throughput, product quality, or economy.

Operating difficulties are analyzed from a technical standpoint and discussed freely with all concerned. In unusual situations, such as the initial startup of a new unit, process engineers work shift work until the usual initial operating difficulties have been overcome.

Process engineers also handle a large portion of the classroom training given operators previous to the startup of a new unit. In addition, they may prepare the operating manual for a new unit. Other technical people, such as the power engineers, work in a similar fashion on mechanical equipment and utilities.

Develop Initiative. As mentioned previously, any difficulties experienced from an operating standpoint are discussed freely among the operators and technical people as well as with the operating foreman. Our real object is to develop individuals who will use their heads in any given situation, emergency or otherwise. Display of interest and holding the unit operators responsible for good performance aids in accomplishing this.

If an emergency occurs, it is later analyzed thoroughly by all concerned and discussed freely with the operators as to how to handle similar difficulties in the future or how to anticipate and avoid them.

Because we are always trying to improve operations from the standpoint of throughput and product quality, things do not remain static for any length of time on any of our units. Changes are discussed freely between the technical forces and the operating people. The operating people thus are consulted before final decisions are made, and quite frequently they make constructive suggestions. At the same time, changes

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are made in the planned procedures as required and any additional safety procedures are included.

Operator Problems. Let us consider for a moment some of the problems associated with the operators on a specific unit. Normally there is at least a head operator, operator, and assistant operator. The head operator is responsible for making certain that work during his shift is completed in accordance with the written daily instructions.

The operator normally operates the unit from the control board. The operator helper usually is an outside man responsible for checking on heaters, pumps, and the like. At lease twice during a shift the head operator makes a complete tour of the unit to check for leaks, frozen steam tracing lines, or any other unusual condition.

When an inexperienced man is assigned to the operating units, he first learns the assistant operator's job. Some formal training in the use of startup, shutdown, and emergency procedures are given him at this time. Experience indicates that this type of training is inadequate and continuous day-by-day attention is required from the head operator who stresses safety factors, preplanned procedures and the need to follow instructions.

Possibly too much reliance on planned procedures can be compared to giving a 16-year-old boy an automobile operating manual. He is told to study and learn it thoroughly. Then he is given a few quizzes, some additional classroom work, a demonstration ride, and finally told to take the "old man's" car, tour the country alone, and enjoy himself.

Training. Periodically, the supervisor also must check on the new operator to confirm that his time is being spent in learning planned procedures, as well as obtaining the benefit of the operating experiences of the other hourly personnel. The head operator and operator cover emergencies and the effect of changing various operating variables.

The dry-run technique wherein the operating foreman poses an emergency-type operation, such as loss of cooling water, then asks each of the operators his proper plan of action is useful as a follow-up procedure. This creates quite a beehive of activity for a few days among the uninformed, and is a good way to get the operating manuals and planned procedures dusted off. There is no definite time interval for these dry runs, but they are employed possibly four times per year on each unit.

Some Go Stale. The majority of unit operators exhibit good interest in the job and try to improve themselves by discussing theoretical emergencies or changes in operations with the more experienced operators, their immediate supervisors, or the technical people. However, some of the operators do not have this quality and tend to become a fixture on the unit because of long experience.

This latter type is likely to fail to anticipate impending difficulties which could be avoided if they properly followed changes in temperatures, pressures, flow rates, and liquid levels. The supervisor must try to improve their performance. We attempted to balance the shift from the standpoint of individual operator quality, but found it to be impractical.

When a real emergency occurs, the operator must be able to analyze the situation immediately and take action. No manual or planned procedure can teach this although it does help. General plans to cover a type of failure, such as loss of cooling water, steam, or electricity, and to cover accepted procedures in case of fire can, and should, be developed. However, when we attempt to cover specific emergencies, the number of possibilities becomes so great that we cannot hope to cover all of them.

Some people react in unusual ways during an emergency. Isolated cases have been known of frenzied arm waving, shouting, aimless running about, or practically becoming transfixed. The individual might even be an excellent "book" operator. Good judgment plays an important role in such a situation and as far as we know good judgment is usually based on previous work and experience, even on corrected bad judgment.

The old saying that mistakes breed wisdom and wisdom begets the knowledge and cunning to avoid future mistakes has application here. We, of course, are not advocating making mistakes to learn how to avoid them, but we are advocating complete discussion of past emergencies or bad operations.

Conclusions. We have tried to show that planned procedures are by no means the whole answer leading to good, safe operations. There is no easy answer.

The answer may be similar to the feeling of confidence you get when you are on an airplane trip and the pilot comes back and chats with the paying customers. If you later run into a little difficulty and he comes back and reassures you, then you still have confidence. But, if, instead, he comes back and starts excitedly thumbing through his operating manual, your confidence rapidly evaporates. We want our operators to have in their heads all the things they need to know from the operating manual, as well as all the other qualities required to get things straightened out quickly.

It takes a good outline of standard procedure, continual diligence, and repeated efforts from diverse starting points to develop an organization that can handle emergencies satisfactorily.

(Originally presented before the midyear meeting of the API, Division of Refining, May 29, 1959.)

About the Author

J. R. Howard is chief process engineer at Eagle Point Works, Texaco Inc., Westville, N. J. He received an M.S. degree in chemical engineering from the University of Tennessee in 1941 and the same year joined Texaco as a chemical engineer in the Research Laboratory, Port Arthur Works. He was later transferred to plant process work and in 1946 to the Refining Department, New York. In 1949 he was assigned to Eagle Point Works and participated in the startup of several new refining units. Howard attained his present position in 1956. His experience with Texaco has involved operating problems on both new and existing units.

The Fine Art of Human Relations

You can buy a man's time. You can buy a man's physical presence in a given place. But you cannot buy initiative—you cannot buy loyalty—you cannot buy enthusiasm. These have to be earned

Stephen G. Henry
Ethyl Corporation, Baton Rouge, La.

TECHNICAL ADVANCES, undreamed of a generation ago, have reshaped the face of United States business during the past 20 years. Yet, almost unrecognized while it was taking place, an even more important change has occurred—a discovery unrelated to the wonders of jet propulsion, electronics, or nuclear energy. It can be summed up very simply: American industry has discovered its employes. It has learned that people literally are the most important asset of any company. And it has begun to realize just how much of its valuable human potential still remains untapped.

The Carnegie Institute of Technology recently completed a research study, lasting more than two years, on business and industry. According to this study, 13 percent of man's business success depends upon his technical knowledge, while 87 percent of his success is due to his skill in human relationships and his ability to lead and get along with people. This skill is the most basic specification for executive attainment and leadership today and opens the gateway to greater human understanding for every businessman, no matter what his particular post in management might be.

It is essential, then, that those who direct the work of others not only have a broad knowledge of the facts and principles of psychology, but that they also be able to analyze work situations in terms of the human factors involved.

Working With People. Management must create a climate in which people will want to produce — a climate in which there is a will-to-work, as there is a will-to-win in sports. Now, to direct your thinking toward what we're going to discuss in working with people, let's look at what some leaders have said about this job of management—of handling people in a refinery, or in a plant, or in any business.

John Ruskin said, "Industrial leaders must keep ever before them these two duties: the making of goods, and the making of men."

Let's look next at the first man to make a billion dollars in the petroleum business. John D. Rockefeller, Sr., said, "Good management consists in showing average people how to do the work of superior people."

Charles Schwab, the first man to be paid $1 million a year (and that was before income taxes, when it was all take-home pay), said that his most precious personal asset was his capacity to arouse enthusiasm among his men because, as he put it, "inspired men have accomplished the impossible. Men saturated with lethargy soon sink into oblivion."

Andrew Carnegie, the steel master, stated, "If you took away my plants, my customers, my capital, in fact my whole physical set-up, but left me my management team, I could re-establish myself in a matter of a few years."

Clarence Francis of General Foods

said, "You can buy a man's time. You can buy a man's physical presence in a given place. You can even buy a measured number of skilled muscular motions per hour or day. But you cannot buy enthusiasm—you cannot buy initiative—you cannot buy loyalty—you cannot buy the devotion of hearts, minds and souls. You have to earn those things."

Yes, we can time-study a man's job, we can give him methods by which he is to do it; but we cannot buy his enthusiasm, we cannot buy his initiative, we cannot buy his loyalty, we cannot buy the devotion of his heart, mind and soul. We have to earn those things.

Dollars Not Enough. So often, these days, we are turning to the psychiatrist for our personal problems. Let's bring the couch into management's office. Here's what Dr. William Menninger of the Menninger Foundation of Topeka, Kansas, says: "Dollars, in any form —salaries, pensions, profit-sharing— are not what people really want most . . . constantly we must remind ourselves that in the final analysis, one simply cannot purchase sincerity, devotion, dedication or loyalty. The most important job satisfaction depends on each having the chance to develop the kind of relationship with his associates that will result in mutual respect and confidence."

The ability to work with and lead people is important. It involves all the "intangibles" of human relations —the motivations, feelings, sentiments, and satisfactions of people. The question of how to best develop this skill or ability is one of the basic problems of management today in its relations to the total economy.

While assembly line techniques have contributed greatly to increases in production and wage payments, they have failed notably in creating satisfaction for the worker, either in his job or in his life outside the factory or office. We know with great certainty how a machine will act under given conditions, but we are not always sure what to expect of the man who operates that machine.

Louis J. Lundborg of the Bank of America said, "With all the progress in engineering and the physical sciences, the human factor is still the most important. The further we go in automation, and the faster we go in developing machines to take the place of people, the more important people become."

Too often we fail to make work human. Management must be made aware of the need of workers to "belong"; to know about company plans, objectives, methods, and accomplishments; to achieve dignity on the job, and pride in their skills; to be recognized as persons, not as numbers. Repetitive tasks will be made meaningful only when men know what they are doing and why.

Now, then, we are saying there must be some job satisfaction, there must be a sense of belonging, there must be that tremendously important item of emotional "take-home" pay. Let's look a little further.

What's In A Name? Let's examine the problem as the Harvard Business School does in its case history methods. Let's look at some typical examples. Dad is at home now, after a day's work in the refinery. Little Johnny crawls up in his lap and says, "Dad, just what do you do out at the refinery?"

Suppose Dad is truthful, and hasn't been there too long—hasn't much seniority nor progressed very far up the promotion ladder. Suppose he tells Johnny, "I'm a third-class helper," "I'm a second-class painter," or "I'm a second-class pipefitter." His work is necessary, and important, in anybody's plant. But, there's not much to be proud of in the name of his particular job, is there?

The name by which we call a man's job and the way we refer to his work are tremendously important. And, with just a little ingenuity, we can do something about it without much cost.

The Hiring of Tony. Let's see how one plant solves this problem. Let's see what goes on at the plant cited by students of productivity as having the highest productivity rate in America, the Lincoln Welding Co. You go to work at the Lincoln Welding Co. by invitation only. You're not hired—you're invited to join the force there! Lincoln hires a little Italian by the name of Tony as what, in other plants, would be a janitor.

Tony is brought in on his first day of work, he is oriented and briefed on what the plant produces, on the importance of these products, and on the people who help make them. He's taken out by his foreman and shown his area of responsibility. Just then, carefully timed, what happens? Mr. Lincoln, the head of that business, during his walk through the plant, stops by and is introduced to Tony.

After the introduction, Mr. Lincoln says to Tony, "I'm glad to know that you are in charge of this area for housekeeping."

Can't you just see Tony, with a broom in one hand and a mop in the other, radiating job satisfaction? That night when he goes home to his wife and the little Tonys, what does he say? "I have worked for Lincoln only one day, and I'm already in charge of an area." He leaves off the housekeeping part of it. He's "in charge of an area."

Pride of Job. Isn't his employer going to get far more work out of that particular man, far more enthusiasm out of him—more loyalty and devotion to the job? Isn't Tony really going to take charge of that area, and tell his fellow workers: "Don't you throw it there. I'll have to pick it up!"

Tony's foreman could have taken him on a tour of his particular area of responsibility, and told him in detail exactly how, and in what order to perform each specific task. Tony would have done as he was told. But, he would have worked me-

chanically. He would have worked without initiative, pride or emotional satisfaction. He would have done exactly what he was told in such detail to do—and no more.

Valuable Lesson. Let's go next to a company in New York City that employs some 7,000 girls. Absenteeism was a major problem. A number of supervisors were trained to interview absentees at home to find out why they were absent. One morning, Jane didn't show up for work. About 10 o'clock a supervisor climbed up to Jane's efficiency apartment, knocked on the door, and was admitted.

The supervisor and Jane exchanged a few pleasantries, and then she asked, "Why did you stay at home today?"

Jane answered, "The problem is simple; I live with my sister who had an unfortunate marriage; there is a baby here; the baby sitter didn't come today."

"Why in the world didn't the baby's mother stay to baby sit?" the supervisor wanted to know.

The girl straightened up and said, "Why, my sister has an important job in a broker's office on Wall Street! If she doesn't go to work, the work piles up and she has to do it the next day. Her job is important. But with you, you have 300 girls in a pool to take my place. It's strange to me that you miss me at all, and that you are out here to see why I didn't come to work."

Think how the absence rate of those girls could have been reduced if that company had used some of the principles of human relations to give their jobs more meaning.

Not long ago, I was talking to the personnel director for the largest oil company in Canada. He said they had had a terrible time getting charwomen in their Toronto general offices. What did he do? He changed the name of the jobs. He changed it to office cleaning ladies. It worked. It solved the problem, not only of getting cleaning ladies, but of getting good ones!

Needed: "Humanation." The president of Stardrill-Keystone Co. does not believe that automation alone will solve our economic problems. He believes that productivity per manhour will not rise fast enough to take care of our expanding need unless it is accompanied by "Humanation." He defines "humanation" as the "full release of human creativeness of the working and managing forces, voluntarily cooperating with each other . . . through organized programs of joint participation in the productive process."

In other words, as Roger Hull of Mutual Life Insurance Co., says: "In the final analysis work is accomplished not by systems, rules, or procedures, but by people. People must be properly motivated if we are to have them draw upon the real wellsprings of their capacities. The greatest and most efficient procedure is one that will inspire people to do the best job of which they are capable."

The emotional security of the worker is no less important than his economic security—and business leadership has to foster both. A sense of security through the feeling of making an important contribution, plus the feeling that the opportunity to contribute will continue, is the truly human feeling of security.

To be a happy, efficient, safe worker, the individual must be given social status and function in the plant community. He must have a sense of purpose, feeling that through his job he is making a contribution to society. He must understand that he is part of an organization which is serving society and furnishing the goods or services that society wants and needs. He must be shown the relationship of his job to the work of the whole organization.

Top to Bottom. At this point some of you may be saying, "I'm not so sure that this philosophy is necessary at the bottom of the totem pole." Do you really think that? Well, I suggest you look up at the top of the pole—the totem pole of management. What do we see up there? Executive vice presidents, senior vice presidents, first vice presidents—and several other kinds of vice presidents.

Isn't it a fact that if you put a few more letters on an office door, and maybe a little wall-to-wall carpeting on the floor, you get more work—and perhaps at the same pay—out of that top man? This is very definitely working today. When any one of the presidents or general managers of a refinery goes down to the local bank to do business, does he want to do business with the office boy? No, sir. There's a vice president, or maybe the executive vice president for the refinery account.

Now, if it works at the top of this totem pole, let's make it work all the way down the pole by recognizing people's pride in a job with a dignified name. It is tremendously important, I want to assure you. However, it's hard to change. Under some union contracts, changing the name or title of an existing job is often all but impossible, but you may want to establish other jobs sometime. When you do, make an effort to put names on those jobs that give them dignity and status so that you don't have "second class anybodies," or "third class anybodies" in your plant.

The "Dog" Shift Incident. Let's go back to the first man who was paid a million dollars a year to work for another man. Let's go with Charlie Schwab when he was a superintendent in a steel mill. Let's go out with him on the "dog" shift. And what is Charlie Schwab doing? He's walking through the plant. That's something! He stops to talk to a man. He shows some interest in him. What does he talk about? Does he ask him how grandmother is doing, or how little Johnny is doing in school, or any of the other paternalistic things that we're supposed to talk about? No!

Charlie Schwab asks, "How many tons of steel have you poured tonight?"

And that man is proud. He says, "Mr. Schwab, we've poured eighteen!"

What does Charlie Schwab do? He pulls a chocolate bar out of his

pocket, and with it writes "18" on the sand floor, and goes off.

When the next shift came to work, the ever-present wiseacre in it asked, "What does that '18' mean?"

The fellow from the "dog" shift immediately answered, "That's how many tons of steel we poured tonight."

And the wiseacre said, "Oh, yeah!'

But what did that new shift do? They poured more steel than the "dog" shift! Charlie Schwab found out what they had done, so he took the "scores" off the floor and put them on the bulletin board, and we had competition.

Let's break down Charlie Schwab's action that night and see how tremendously important it was. First, he walked through the plant—tremendously important. Secondly, he spoke to a man—he was interested in that man. He asked him about his work—"How many tons of steel have you poured tonight?" Then he did something about what that man told him. Charlie Schwab didn't realize that he was creating something that was going to carry that same crew to 36 tons of steel in an eight-hour shift!

Emotional Pay. One reason we have trouble in industry is that we've had to "de-skill" our jobs in order to simplify training. Look at the automobile industry in its assembly line work. What do the workmen do? One man picks up a nut, puts it over there. Another man picks it up and starts it on the stud. Another man runs it down with an air wrench. Another man gives it a pull with a friction-loaded torque wrench, so that it is drawn up with the right degree of tightness. It takes four men to get one nut on. Is there any emotional take-home pay for those particular men?

A vice president of General Motors once told me, "It's so hard to tell a man that he's built an automobile when he's put one screw in one hinge on one door."

Yet, you can do it! No matter what a man's job is, you can impress him with the importance of the product, the importance of getting the job done, the importance of timing, the importance of movement—you can make sure that he has some emotional take-home pay.

Job Satisfaction. Let's look now at some research findings by the University of Michigan last year on "The Keys to Happiness in Jobs in the Utility Companies." What personal satisfaction, other than good pay, makes a job worth while? There are five sources of satisfaction, according to this detailed study involving interviews with 2,500 employes.

1. *Recognition:* the need to feel that one's achievements are made known to others — a little bit of recognition for a job well done—was first. Remember, Charlie Schwab wrote "18" down on the floor, then moved it to the bulletin board, and the race was on.
2. *Achievement*: the need to feel that one has done something worth while or important—was the second source of satisfaction.
3. *Autonomy*: the need to feel that one has responsibilities and power in one's area of action was third. Remember Tony, in charge of his area for housekeeping.
4. *Affiliation*: the need to have friends and be in communication with others.
5. *Evaluation*: the need to feel that there are reasonable standards for judging work in a particular plant.

What are we talking about? First, we are talking about human dignity. Everyone wants to be somebody. Everyone wants to be important, no matter in what level of society he is. We want some job satisfaction from the work that we're doing. It doesn't matter whether you're the newest janitor, or whether you're an executive vice president at the top of the totem pole. You want that sense of belonging. You want to feel the importance of the contribution that you're making to your company, and to society in general.

Let's go back and say again, if we want to destroy a man's usefulness, give his job the character of uselessness.

Keep Employes Informed. How many men in your plant realize that 80 percent of all drugs are petroleum derivatives, that 98 percent of all the plastics produced in this country are from petroleum; that our consumption of plastic is nearly up to our consumption of steel; that 60 percent of all rubber and 62 percent of all soaps and detergents come from oil; that 27 percent of all textiles in this country are petroleum derivatives?

Does that man of yours fully realize the tremendous importance of the petroleum industry? Does he know that in 100 years we have grown from two oil products to over 2,500? Does he realize that petroleum affects him from the cradle to the grave? Does he know that the baby oil that he is first rubbed down with when he comes into this world is a petroleum derivative? Does he know that the hydraulic oil that lets his casket down into the earth is also a petroleum derivative?

It's tremendously important that we talk to people, that we know people. What's worse than a situation in which a plant manager, a refinery manager, or a supervisor has an employe who's been with him three, four, five years—a man who passes him in the hall and nods at him, and whose name he doesn't know? I visited a headquarters in which a man told me, "I have worked for so-and-so for eight years, and he doesn't even know my name!"

Foothold for Unions. I'd like to quote from *Dynamics of Industrial Democracy,* by Clinton Golden and Harold Ruttenberg, et al. Who are they? They're professional negotiators for small companies—professional contract negotiators for 828 firms employing 660,000 people. These men say in their report:

"One of the compelling motives for union membership (and we're talking about small companies) is the desire of workers for personal

. . . employes want to be treated as human beings

dignity and for some meaning to their lives. They join unions to become something more than a number that is ordered around as a piece of material is moved. They crave to be recognized as human beings, to be treated with respect, to be given the opportunity to find satisfaction in their daily work through the free play of their inherited creativeness, to win the praise of their fellow workers, and to secure personal recognition and advancement of their ideas. The dynamic quality, the militancy, and the crusading spirit of the labor movement in the last decade, were nurtured by the failure of management to satisfy the non-economic needs of the worker."

If you take nothing away with you from this article but one thought, remember that the non-economic needs of the worker must be met.

Management's Fault. Some time ago the *Reader's Digest* asked people to write them on "What's Wrong with Management?" There were 8,000 workers who did. The answers they gave to that question had a dominant theme. It was: "I'm a human being, not a machine. I'm a partner in American war production; why can't management treat me as such? We are supposed to be shoulder to shoulder in a democracy, but management does not act that way. Management does not realize that we are human beings."

Let's go next to the Gallup Poll, one of the American samplers of public opinion. I'll quote only one paragraph:

"The general public thinks there are about as many things wrong with employers as there are with unions. The chief complaint of these employes was not what you might expect — low wages. More people named a broader, more inclusive fault. It is summed up in one reply, which was typical of the thousands that were sent in: 'Management hasn't got enough understanding of working people and their problems. Businessmen keep thinking of labor as a commodity instead of as human beings. The reason people join unions is that they feel the boss won't pay any real attention to the welfare of the worker if left to himself. He's got to be forced to do things'."

It's a sad commentary on American leadership when the workers still are asking that they be treated as human beings in the place where they work. There is the economic motive for which there are countless illustrations in terms of major increases in output and reduction in operating costs. One company alone saved half a million dollars in the cost of accidents in a two-year period through improved personnel administration — through handling people better.

About the Author

Stephen G. Henry (Maj. Gen., U.S.A., retired) is manager of community relations for Ethyl Corp.'s Baton Rouge manufacturing plant, where he directs press, radio and TV relations, and edits a company news bulletin and plant magazine. In 1916 he was commissioned a second lieutenant, Louisiana National Guard. After receiving a B.S. degree from Louisiana State University in 1917, he served during World War I in France and Germany. Following the war he attended numerous Army schools and did graduate work at Massachusetts Institute of Technology. Henry conceived, organized and operated one of the largest technical schools in the United States —the Armored Force School, Fort Knox, Ky., with a peak enrollment of about 40,000 students.

He served overseas during World War II in Africa, Italy, France, Germany and the Western Pacific Theater and on General George C. Marshall's staff as the War Department's first director of research and development activities. Later he was assistant chief of staff for personnel.

Henry retired from the Army in 1946 and joined Ethyl in 1947 as special assistant to the vice president in charge of manufacturing. He was named manager of plant and employee services in 1947, a position he held until his current appointment in 1951.

Role of Supervisor. The foreman or the immediate supervisor of each individual is the key man. At all levels in the organization, a worker's immediate superior is the one who translates to him the policies and problems of the company and even its dreams and aspirations. It is the supervisor who converts top management's ideas into the human terms that will be understood by the people he supervises. So long as good human relations are practiced at every level in an organization, that organization is likely to have good morale and spirit plus understanding and respect for management's decisions.

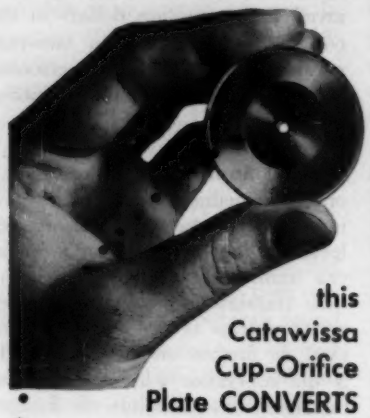
Before closing, let me summarize for you the major points I have tried to bring to you about dealing with people—about human relations in your industry.

First, we must remember that employes want to be treated as human beings. They want recognition, a sense of achievement, autonomy, affiliation, and some sort of evaluation of their contributions to their company.

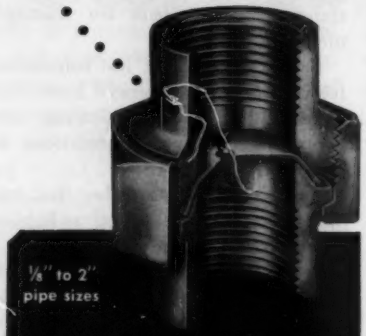
Second, there are ways you can help your employes obtain those desires. Tell them about the importance of your business and their importance to that business. Assure them job satisfaction by assigning them responsibility. Consider the names that you give to their jobs. Know your people and let them know of your interest in them.

And, above all, remember that you have the responsibility of going a step beyond providing their material or economic requirements. You have the responsibility of satisfying the many non-economic needs of those employes by looking at some of the requirements of job satisfaction and the improved productivity that goes with that satisfaction. # #

here's real **ECONOMY...**
time-saving **SIMPLICITY...**
and sure-fire **DEPENDABILITY**
for metering, measuring, controlling any piped material!



this Catawissa Cup-Orifice Plate CONVERTS any standard Catawissa Union into a ***GASKETLESS*** **ORIFICE UNION**



ELIMINATES the necessity of expensive gaskets...the uncertainty of what type gaskets are needed for specific temperature and pressure requirements... fumbling with extra parts!!!

Orifice Union problems of the past are gone forever! Stainless or carbon steel cup-orifice plate fits easily, quickly, securely to form a good, tight, leakproof seal. Temperature and pressure requirements are restricted only by the rating of the union itself (3000-lb. service, 9000-lb. test)!

Just specify "Catawissa Cup-Orifice Plates" or "Catawissa Cup-Orifice Unions" at your favorite supply store—or write for catalog and complete information.

CATAWISSA VALVE & FITTINGS CO.
CATAWISSA • PENNSYLVANIA

New Books...

The Age of Illumination

"The American Petroleum Industry" (1859-1899, The Age of Illumination) traces the growth of the American Petroleum industry from 1859, when the Drake well was drilled at Titusville, Pa., until the end of the 19th century, when the age of kerosine illumination ended and the gasoline age began.

It is the first modern study that encompasses all facets of the early development of one of the nation's most important industries, and relates the development of that industry to a position in world leadership. The volume shows that this rise was made possible in a large measure by the imaginative use of abundant U.S. oil resources for the production of efficient and inexpensive illuminants, lubricants and fuels.

This book is an authoritative account of the pre-history and hectic early days of petroleum—its growing pains, initial technological development, and challenge of the first formidable foreign competition. Included are 150 maps, diagrams and photographs that depact leading industry personalities and illustrate important industry developments.

(Williamson, H. F., and Daum, Arnold R., *The American Petroleum Industry*, Northwestern University Press, Evanston, Ill., 864 pages, $7.50. For Sale by Gulf Publishing Co., P. O. Box 2608, Houston 1, Texas, U.S.A.)

Fuels and Lubricants

Fuels and Lubricants" surveys the field of important fuels, including boiler, internal combustion engine, and jet fuels, as well as rocket propellent and nuclear fuels. It also discusses the desirable properties of fuels and lubricants, the ASTM tests which are used to measure the properties, and the interpretation, limitation and significance of these tests.

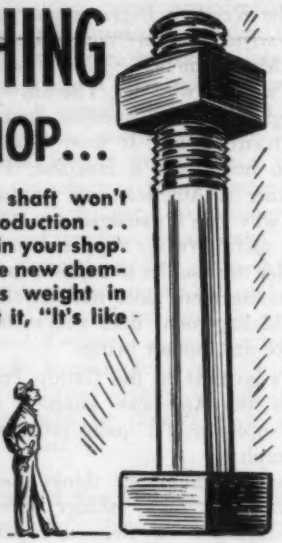
(Popovich, Milosh, and Hering, Carl, *Fuels and Lubricants*, John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 312 pages, $8.50. For sale by Gulf Publishing Co., P. O. Box 2608, Houston 1, Texas, U.S.A.)

Petroleum Refining Text

"American Petroleum Refining" shows why, how and when modern processes and equipment were developed for the refining division of the oil industry. It includes information on the chemical and physical properties of hydrocarbons, the characteristics of crude oils and products, and the relationship of auxiliary services such as power, water, waste disposal and fire protection. Material on processes is helpfully complete and up-to-date with flow charts and operating date.

The author avoids deep theoretical discussions and arduous examples. Thus, men in one refining department can easily learn what is done in another,

BIGGEST THING in YOUR SHOP...



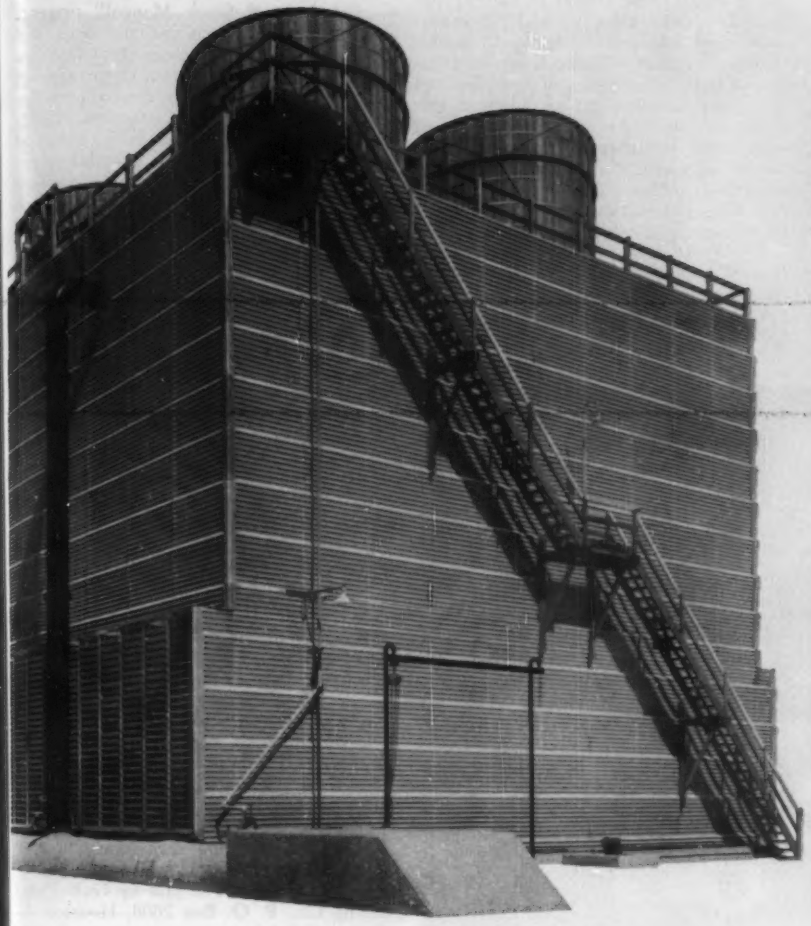
When some rusty bolt or shaft won't let go and it is tying up production . . . it can be the biggest thing in your shop. That is when Kano Kroil, the new chemical loosener, is worth its weight in gold. As one customer put it, "It's like an extra employee."

. . . "Five men, total weight of 825 pounds, using levers and sledges, struggled for an hour with a frozen shaft. No luck. So all went out for a smoke. One man, weighing 140 pounds used Kroil and by the time we returned, had lifted the shaft out with no leverage."

You Too Can Get This Result

Try Kroil at our risk. If it doesn't do more than you expect, return it and the charge will be cancelled. Get the Kroiler combination, one gallon of Kroil (regular price $4.00) and Kroiler squirt gun for $4.95 f.o.b. factory. Order direct.

KANO LABS. 1094 S. Thompson Lane Nashville 11, Tennessee



FLUOR COOLING TOWERS

higher thermal performance

lower maintenance cost

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etc. *

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Fluor PRODUCTS COMPANY

INDUSTRIAL COOLING TOWERS

A division of The FLUOR CORPORATION, Ltd.

GENERAL OFFICES:
SANTA ROSA, CALIFORNIA

For more data on advertised products, use Readers' Service Cards, last page.

Books . . .

while students of petroleum technology will find information on the refining branch of the industry.

(Bell, H. S., *American Petroleum Refining*, D. Van Nostrand Co., 120 Alexander St., Princeton, N. J., 538 pages, $12.50. For sale by Gulf Publishing Co., P. O. Box 2608, Houston 1, Texas, U.S.A.)

Organic Sulfur in Gases

"Identification and Determination of Organic Sulfur in Utility Gases" discusses the analytical methods for accurately determining types and amounts of organic sulfur compounds present in natural and manufactured gases. Methods described have been sufficient sensitivity to permit determination of sulfur compounds present in concentrations of less than one grain per hundred cubic feet of gas. Research and experimental evidence on which the selection of procedures was based are given, and the apparatus and analytical methods are described in detail. This information will be of value to those concerned with gas analysis.

(AGA, *Identification and Determination of Organic Sulfur in Utility Gases*, American Gas Association, 420 Lexington Ave., New York 17, N. Y., 51 pages, $5.00.

Petroleum Refinery Manual

Petroleum Refinery Manual" presents complete information on planning and constructing new refineries. Included are preliminary considerations, engineering (estimating, scheduling, mechanical design, etc.), and field construction. A unique feature of the book is its attempt to specify the number of man hours required for each phase of new refinery construction. Examples of finished work are described which furnish useful standards of comparision for new work.

Figures covering capital investment, operating manpower and operating costs accompany the descriptions and diagrams of all modern refining processes. There is more emphasis on the newer processes, although former methods are outlined for comparison purposes.

(Noel, Henry M., *Petroleum Refinery Manual*, Reinhold Publishing Co., 430 Park Ave., New York 22, N. Y., 182 pages, $7.95. For sale by Gulf Publishing Co., P. O. Box 2608, Houston 1, Texas, U.S.A.)

Phenolic Resins

"Phenolic Resins" concisely discusses the raw materials, production methods, and applications of the phenolic resins. The book emphasizes the practical features including commercial and economic considerations. Numerous disclosures in patents and elsewhere serve as a basis for the development of new uses for the phenolics. There is also information on the use of phenolics in combination with other resins.

(Gould, David F., *Phenolic Resins*, Reinhold Publishing Co., Department B-298, 430 Park Ave., New York 22, N. Y., 213 pages, $5.75. For sale by Gulf Publishing Co., P. O. Box 2608, Houston 1, Texas, U.S.A.)

Analyses for Phthalics

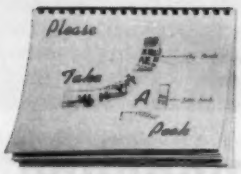
"Volumetric Determination of Phthalic Anhydride in Certain Modified Alkyd Resins" (PB 151526) discusses a method useful for determination of phthalic anhydride and the isomeric phthalic acids in all types of modified alkyd resins. The technique involves nonaqueous titration.

(Esposito, G. G., *Volumetric Determination of Phthalic Anhydride in Certain Modified Alkyd Resins, PB 151526*, Office of Technical Services, U.S. Department of Commerce, Washington 25, D. C., 8 pages, 50 cents.)

Foreign Operation Finance

"Financing Foreign Operations" reveals many sources of capital to help companies keep pace with expanding overseas business. Services and funds available from the U.S. Government and from international lending organizations are described in detail. The role of the private money market in financing foreign operations is also discussed by financial specialists and executives. The book also shows how to meet specific financial needs; how to finance foreign plants in local currencies, how to finance international operations for a capital-goods

3 BENDS in 15 MINUTES
On 4" EXTRA Heavy Pipe



"TAKE A PEEK" BOOKLET Free

Rotary, Ram and Roll Benders in the world's largest size range, are described and shown in action. It's the kind of booklet you will like to have at your finger tips when thinking of plant extensions or new jobs. *Thanks for the privilege of sending it to you.*

With the Wallace-Tubela Portable Ram Bender

The open top construction makes loading easy. Power ejection of bent parts gives this machine the fast, positive, low cost action needed for maintenance. A wonderful "second" machine to have around. Let us send you complete specifications on all four models.

WALLACE SUPPLIES MFG. CO.
1806 Cornelia
Chicago 13, Illinois

WALLACE HAS MEANT QUALITY MACHINERY SINCE 1896

MORE THAN MEETS THE EYE

Pastel and bright color combinations used in this Hudson designed and built plant are utilitarian and also pleasing to the eye.

But beyond the eye appeal is the built-in 30 years experience of Hudson in building gas processing plants in most gas producing regions of the free world.

Such experience combined with constant alertness for improvements results in trouble-free plants, built on time, with careful balance between capital cost and operating cost to assure maximum return on the investment.

The above pictured absorption plant processing 300 million cubic feet per day of gas at about 1000 pounds pressure is located on the Mermentau River in Cameron Parish near the Louisiana Gulf Coast, and was designed and built for the Superior Oil Company.

A refrigerated absorption process is used with provision for future further refrigeration down to minus 50°F to increase gas throughput and/or product recovery. The plant has operated uninterruptedly since initial test start-up in October 1958.

DESIGNERS AND CONSTRUCTORS OF PROCESS PLANTS FOR THE OIL, GAS, CHEMICAL, AND MINERAL INDUSTRIES

HUDSON

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Through the reports issued by the Audit Bureau of Circulations, this publication, along with other publisher members of ABC, voluntarily and regularly give the buyers of advertising more verified factual information than is available for any other advertising media at any time.

Certainly We're Sure — it's an ABC publication!

Once upon a time advertisers were, whether they liked it or not, perforce speculators.

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This publication is a member of ABC. Its circulation is audited by specially trained circulation auditors and reported in accordance with standards established and maintained by ABC—the highest standards of advertising value.

Buyers of advertising can be sure how much circulation this publication has, where it goes, how it was obtained, how much readers pay to see it, and other FACTS that tell them what they get for their advertising money.

It pays to be ABC-audited sure!

PETROLEUM REFINER

producer, how to finance industrial enterprises in Latin America, etc.

This report is based on material originally presented at an orientation seminar held by AMA's International Management Division in 1958.

(AMA, *Financing Foreign Operations,* American Management Association, 1515 Broadway, Times Square, New York 36, N. Y., 163 pages, $3.00 for AMA members, $4.50 for others.)

Cost Reduction Report

"Cost Reduction At Work" is a report of successful company practices.

The rising cost of production is cutting drastically into profit margins. More than ever, companies are recognizing the need for immediate and continuing programs of cost reduction and control.

In this report, companies that have substantially reduced manufacturing costs explain how they did it. Representatives of small, medium, and large-sized companies describe factually such cost-cutting tools as systems engineering, work measurement, and value analysis.

The report also includes case studies of successful cost reduction. An approach to cost reduction through work simplification is explained by E. I. du Pont de Nemours & Co., Inc. How the purchasing function can contribute to cutting costs is discussed by the United States Steel Corp. (Columbia-Geneva Steel Division). This report is based on material presented at two special conferences held by AMA's Manufacturing Division in 1958.

(AMA, *Cost Reduction At Work,* American Management Association, 1515 Broadway, Times Square, New York 36, N. Y., 84 pages, $1.50 for AMA members, $2.25 for others.)

Equilibrium Compositions

"Table of Equilibrium Compositions of $(CH_2)_n$ + Air Mixtures" gives the equilibrium compositions of the product gases for various mixtures of $(CH_2)_n$ + air at a number of temperatures and pressures. An explanation of the method of calculation and a numerical example are given. Included also is a table of the thermodynamic properties of the product gases.

(Naumann, R. K., *Table of Equilibrium Compositions of $(CH_2)_n$ + Air Mixtures,* Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C., 99 pages, $2.25.)

Free Book Catalog

For a free copy of our book catalog write to BOOK DEPARTMENT, GULF PUBLISHING COMPANY, P. O. Box 2608, Houston 1, Texas. Often books reviewed here may be purchased from this source.

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THREADEZY

FOR HAND and POWER MACHINES

A New Era... In Cutting Oils!

A SUPERIOR GRADE AT POPULAR PRICES

DARK or CLEAR

IMPROVES THREADS
INCREASES DIE LIFE

IN 5, 30 and 55 Gallon Drums, Gallons, and Handy Quart Sizes

CHANGE TO ▶ IT'S ANTISEPTIC

CALL YOUR Mr. TOLEDO NOW
(Sold only Thru Authorized Distributors)

OR WRITE TO:

PIPE THREADERS • PIPE WRENCHES • PIPE MACHINES

TOLEDO

TOLEDO PIPE THREADING MACHINE CO. TOLEDO 4, OHIO

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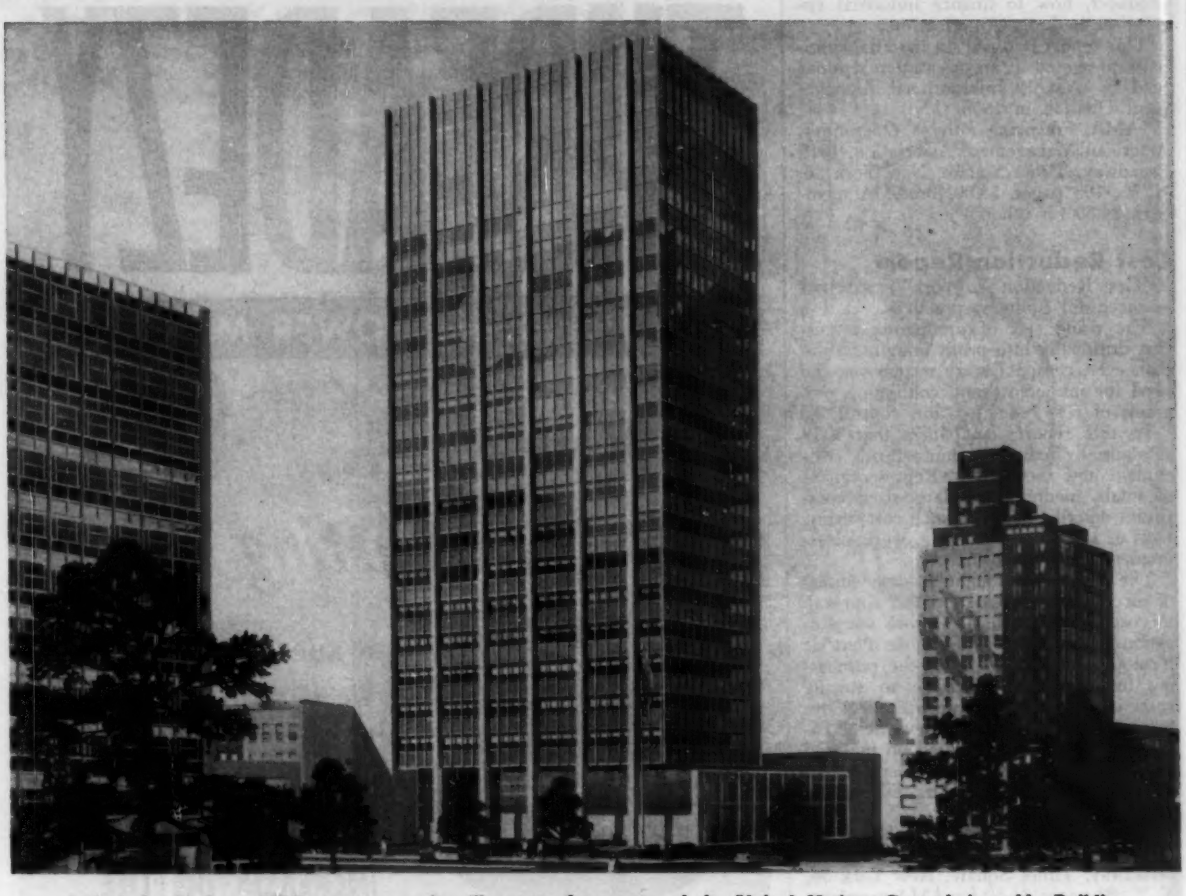
What's Happening...



Artists' sketch shows UEC structure as it will appear from steps of the United Nations General Assembly Building.

Ground Broken for Engineering Center

Building, which will house headquarters of 18 key engineering societies, will be completed in 1961

GROUND BREAKING ceremonies for the United Engineering Center, a $12-million, 18-story structure to be erected opposite the United Nations in New York, were held October 1. Former President Herbert Hoover shared earth-turning honors with a freshman engineering student from Hawaii, Jerry Fujimoto, representing engineers of the future.

To occupy the block between 47th and 48th Streets, on United Nations Plaza (First Avenue), the Center will house the headquarters of 18 major engineering societies with a combined membership of more than 300,000. Together, the societies are responsible for a major part of the nation's technical publications, industrial standards and engineering conferences. Some of the groups are now housed at the Engineering Societies Building, 29 West 39th Street.

Fujimoto, an American citizen of Japanese extraction, enrolled this fall at Rensselaer Polytechnic Institute. He is a member of the newest engineering class, entering the oldest engineering college in the country from the newest state in the Union.

Several thousand persons attended the October 1 ceremonies, including representatives of foreign engineering groups. Major excavation work will begin later in October.

Plans for the Center, which is scheduled for completion in mid-1961, have been over eight years in the making. A fund-raising campaign has already achieved nearly $5 million in

Passes even the "white glove" inspection— Thanks to Dowell's new standard of cleanness

You may never have occasion to place "white glove" requirements to the cleanness of your process equipment, steam generators, tanks and piping. But, if you do need this high degree of cleanness, Dowell can now offer it — as an additional service — in the chemical cleaning of *your* plant equipment.

Dowell developed these new standards in cleaning the piping networks of the missile launching facilities at Cape Canaveral. Combining the research and engineering facilities of the entire company, Dowell perfected new techniques, materials and equipment to meet the necessary rigid specifications.

This new service is now adaptable for use in all types of American industry. For example, Dowell recently performed an intricate cleaning job on a 3½-mile-long buried pipeline. The customer wanted to convert the six-inch line from hydrocarbon gas to carry oxygen. For this pure product the line had to be immaculate—free of all foreign materials. The plant was faced with the alternate of laying new pipe—a six week job at a cost of $150,000.

Using their new standard of cleanness, Dowell cleaned the line of hydrocarbon residues, carbon black, grease, mill scale, and rust. Meanwhile, plant crews made mechanical alterations to the line at a cost of about $25,000. Dowell's charge was $20,000; the job was done in 3½ days.

The job was satisfactory in every way. Inspection showed the line was free of all foreign matter. The customer credited Dowell with saving them about $100,000. Also the plant made additional profits because the line was put back into use so quickly.

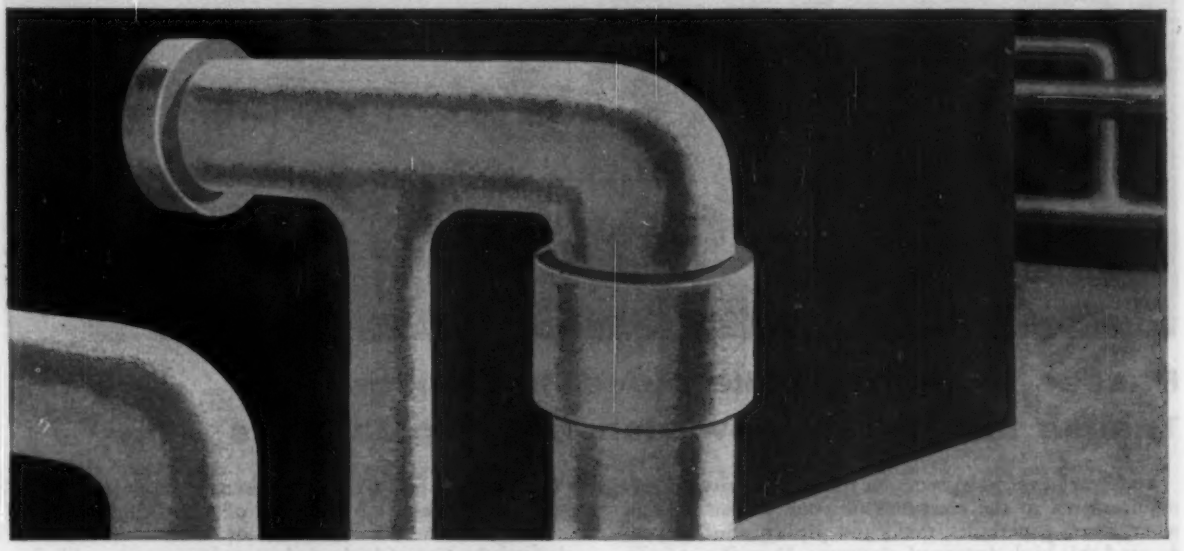
Ask your Dowell representative about these new standards of cleanness and their possible application to your problems. This exclusive Dowell service may save you important money. Dowell, the pioneer of chemical cleaning, has 165 offices to serve every major industrial center. Dowell, Tulsa 1, Oklahoma.

Chemical cleaning service for all industry — DOWELL

DIVISION OF THE DOW CHEMICAL COMPANY

For more data on advertised products, use Readers' Service Cards, last page.

ONE QUICK APPLICATION INSULATES, PROTECTS, FINISHES!



EAGLE-PICHER
ONE-COTE CEMENT

Eagle-Picher produces a complete line of industrial insulations for all temperatures from below Zero to over 2000 F.

EAGLE EP PICHER

Since 1843

The Eagle-Picher Company

Dept. PR 10, Cincinnati 1, Ohio

(Member National Insulation Manufacturers Ass'n)

- Saves time, work, money! One quick application provides smooth, light reflectant surface on hot or cold equipment!
- Clean, easy to handle! Just trowel it on—even on irregular areas where application of other insulations is often impractical.
- Highly efficient! Effective insulation at temperatures up to 1000 F.
- For outdoor installations! Quick-setting, withstands rain and moisture two hours after application. Prevents rust!
- For indoor installations! Requires no wire mesh or finishing treatment!

contributions for industry and $3 million in contributions from individual engineers.

Andrew Fletcher, president of United Engineering Trustees, the organization that will own and operate the structure on behalf of the engineering societies, said that, "the primary purpose of the new structure is to provide adequate working space for the headquarters staffs of the engineering groups, which carry on extensive publishing, research and standardization programs." The second purpose, he added, "will be to symbolize the growing strength and growing unity of the engineering profession."

Land for the structure was acquired in 1957. Since that time, major efforts of UET have been directed toward design of the building and fund-raising activities.

Sohio Executive Points Out Importance of Mid-East Oil

If there were no Middle East oil or if it should become unavailable in the world markets, the price of gasoline would be higher than the generally prevailing price at service stations. Speaking at a large civic luncheon in Columbus, Ohio marking the meeting there of The Standard Oil Company (Ohio) board, Samuel H. Elliott, senior vice president, exploration and production, outlined "The World of Oil." He pointed out that the United States is consuming about half of all the oil produced in the free world while having only about 1/7th of the proved reserves. Moreover, the cost of finding oil abroad is substantially less than finding it in the United States and the cost of producing it is likewise relatively low.

Average production per well in the Middle East is 4,000 bpd and in Venezuela it is 270 bpd compared with 12 bpd in the United States.

Standard Method of Grading Fuel Oil Is Developed

A standard method of grading fuel oil for home burners has been developed through the use of a "toy" furnace. Cleaner, more efficient fuel and information leading to improved burner design are other promises of the new "Micro Test Burner," a scaled-down version of the common heating unit, reported R. A. Billmeier, a chemist for Socony Mobil Oil Co., Brooklyn. The prototype already has made it possible to work out a test for combustion index, and this index gives an indication of the amount of smoke that will be produced in full-scale equipment, he said.

Smoke is an expensive impairment of burning efficiency, Billmeier pointed out. Although standards have been established which classify oils as to grade of refinement and suitability for various types of burners, no practical combustion test is available to measure the smoking tendency of a household fuel.

"The expected yardstick for measuring

WITH

TAYLOR-WHARTON

The flexibility of MOBILIZED GAS STORAGE can now be yours with low-cost Taylor-Wharton Gas Transports. With these mobile storage units, you can eliminate the expense of charging remote permanent storage systems and greatly reduce initial cost and maintenance.

The heart of the Transport is a group of Taylor-Wharton seamless steel pressure vessels. Their quality, established by closely controlled manufacturing processes and rigorous inspection, makes the Taylor-Wharton Transport a sound investment in durable, up-to-date equipment. All vessels are normalized for extra safety and manufactured to I. C. C. 3A2400 specifications. Available in capacities of 38,500 to 56,000 cubic feet, the vessel groups are rigidly mounted on modern single or tandem-axle trailers. A weatherproof rear housing protects the valve and manifold system.

Catalog No. 58 gives complete details on this practical system for flexible gas storage. Write for it today.

More than a Century in Harrisburg 2, Pa.

H HARRISBURG STEEL CO.

Division of HARSCO CORPORATION

CYLINDERS TUBES FLANGES COUPLINGS

For more data on advertised products, use Readers' Service Cards, last page.

Self-propelled Austin-Western 210 hydraulic crane handles length of fabricated pipe in unpaved storage yard.

Louisiana piping fabricator says:

A-W 210 crane proves indispensable; saves $8000 cost of overhead crane!

"I was impressed with the speed and all-around usefulness of Austin-Western hydraulic cranes when I observed them at a refinery construction project several years ago," explains B. L. Vowell, general manager of Southeast Fabricators, Inc., Baton Rouge, La.

Maneuverable; precision control

"When we laid out our plant, we planned to use an A-W for outside work and install an overhead crane inside the shop," he tells us. "However, the Austin-Western has proven so maneuverable and fast, and capable of such a high degree of precision control, even inside the shop, that we have abandoned the idea of ever installing an overhead crane—thereby saving approximately $8000!

"All-wheel steering and low overhead clearance permit the operator to maneuver the crane into the tightest spots imaginable . . . and the telescoping boom can reach out in any direction for accurate pickup and placement of materials.

"The fast working speed of the crane directly influences the flow of work through the shop. There isn't a single phase of our operation which doesn't depend on the A-W. It's indispensable. I frankly don't feel that we could get along without it.

Downtime extremely low

"Downtime has been extremely low—less than 2½ days in two years! Only normal maintenance is required. The unit works a 40-hour week. It's never idle for longer than 10 or 15 minutes at a time. We're very well pleased with the Austin-Western and recommend it highly."

Learn how A-W hydraulic cranes can profitably fit into your operations. Now available in several capacity-ranges and boom lengths—many optional attachments for even greater versatility. Get full facts; arrange for a demonstration. Write us today for the name of your nearest Austin-Western distributor.

Ask about new models now!

Austin 100th YEAR Western
CONSTRUCTION EQUIPMENT DIVISION, AURORA, ILL.
BALDWIN · LIMA · HAMILTON
Power graders • Motor sweepers • Road rollers • Hydraulic cranes

Happenings . . .

combustion quality, analagous to the octane rating for gasoline, would lead to continual improvements of fuel oils and perhaps a way of predicting in advance the performance of fuel in a particular type burner," Billmeier added.

"Unlike a full-scale burner, the miniature furnace is capable of very fine adjustment and clearly differentiates between performance related to fuel composition and that related to equipment design."

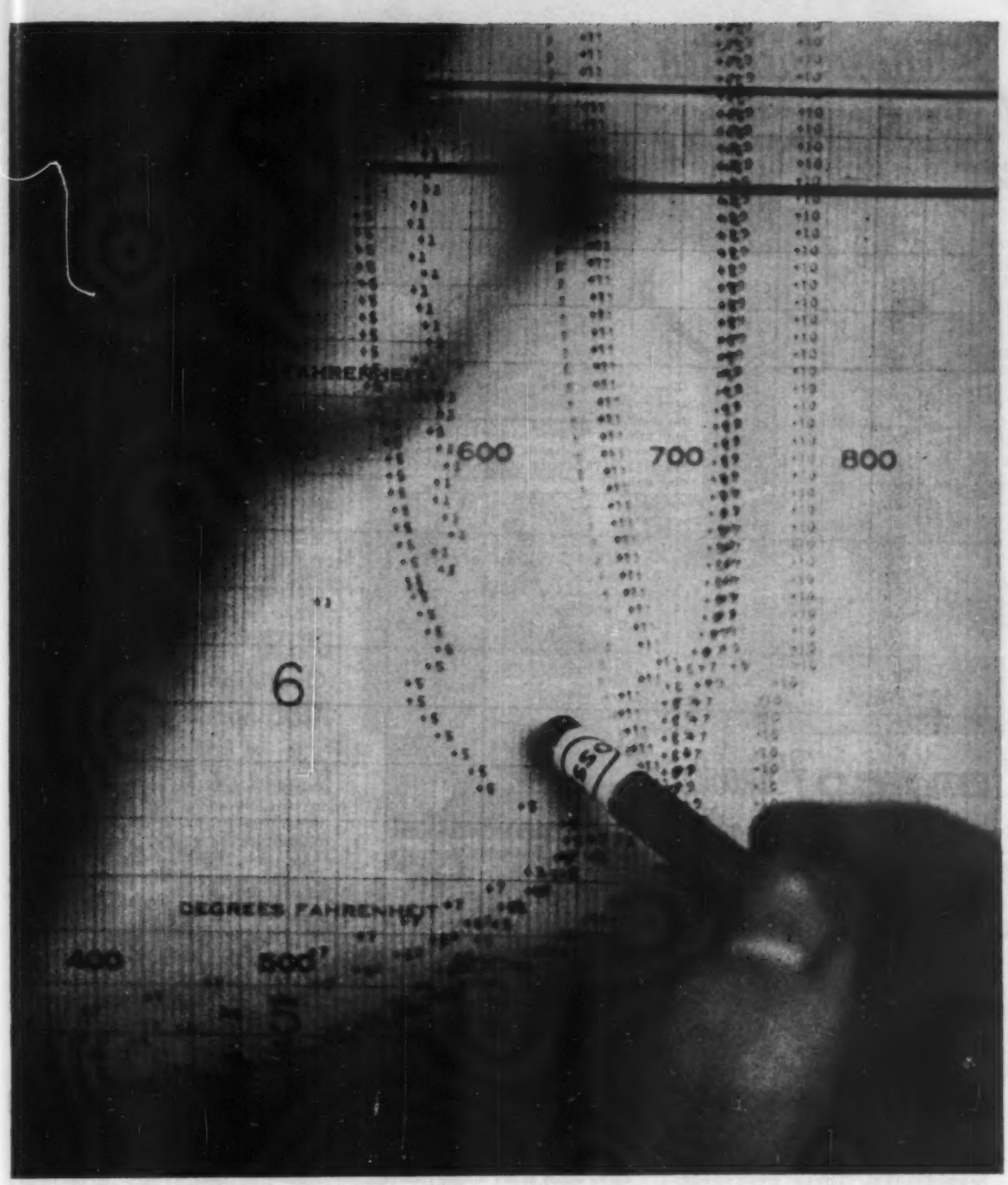
The pint-size burner uses only one percent as much oil as the home-type burner, and its combustion chamber is only 1½ inches wide and 9 inches long. Oil is fed into a specially designed nozzle with a high-precision displacement pump. An air stream under slight pressure meets the oil within the nozzle, resulting in an atomization similar to that occurring in conventional equipment, according to the chemist.

"The need for a dependable miniature laboratory oil burner which would permit combustion under closely controlled conditions has long been obvious, but there have been many obstacles in perfecting devices to obtain fine measurements," Billmeier noted. The new prototype greatly reduces testing time and, for the first time, makes it possible to study small samples of expensive experimental fuels.

Jet Fuel Provides More Thrust, Low Luminosity

A revolutionary development in jet aircraft fuel that promises to increase aircraft lifting power, extend non-stop flight range and engine life, as well as virtually eliminate exhaust smoke on take-off, has been disclosed by L. C. Kemp, Jr., vice president in charge of research, Texaco Inc. The new Texaco jet fuel has what Kemp described as extremely low luminosity, a property only recently discovered to be critical in jet aircraft fuels.

Two different fuels, Kemp explained, can burn equally hot and yet one be more luminous that the other. For example, ordinary kerosine burns with a visible, or luminous, yellow flame whereas an equally hot pure hydrogen flame cannot be seen. The reason for this, he added, is that incandescent molecular fragments are formed in the kerosine flame, causing it to glow or to become luminous. These luminous fragments give off radiant heat, which can seriously increase hot metal temperatures inside a jet combustor without adding to engine power. "The new low-luminosity fuel solves this problem by sharply decreasing radiant heat given off inside the engine's combustion chambers. The new fuel can thus be burned at higher temperatures than conventional fuels without overheating the engine. Hence the jet can develop greater thrust at take-off, increasing its lifting power and payload, and it can run cooler in the air, increasing engine life. Moreover, the new fuel virtually eliminates the exhaust smoke on take-off



"... It is not enough for a company to put out good products at a fair price. To compete successfully, it must demonstrate ability to keep up with and contribute to the technological revolution. This means new techniques, new processes, new products to capture the imagination and the dollars of the buying public."

— M. J. Rathbone, President

Esso

Standard Oil Company (New Jersey)

and affiliated companies

For more data on advertised products, use Readers' Service Cards, last page.

'Steam Jacketed' for ASPHALT TRUCK LOADING

Close-up view, above, shows 4" Barco "Jacketed" Ball Joint on asphalt loading arm. Note counterweight extension on joint. This single joint provides for 360° vertical swivel movement and 30° horizontal flexibility. (Photos: PHILLIPS PETROLEUM COMPANY, Kansas City, Kansas)

BARCO Flexible Ball Joints

Here is another of the numerous refineries that are now using Barco's new STEAM JACKETED Flexible Ball Joints in piping lines handling asphalt. Steam heat makes it possible to load trucks in a fraction of the time otherwise required. Pumping loads and strain on pipes are reduced. Messy handling conditions, use of live steam jets, and the possibility of stopped up lines are also eliminated.

Barco produces the ONLY complete line of "jacketed" flexible joints that can cope with such tough loading conditions. Users report savings running into thousands of dollars for time saved and simplification of piping requirements. These permanent, maintenance-free, labor-saving installations eliminate the problem of rapid deterioration and frequent maintenance encountered with hose.

For recommendations on how to use Barco Flexible Ball Joints, ask for a Barco engineering field representative — located in principal cities.

FEATURES

COMPLETE LINE — Barco Steam Jacketed Flexible Ball Joints are now offered in 2", 3", 4" and 6" sizes.

TO MEET YOUR NEEDS — Straight and angle; screwed and flanged styles, or welding ends. Steel casing.

FLEXIBILITY — The ball provides more than 30° total angular movement in any direction.

VERSATILE — For handling asphalt, molten sulphur, and other heavy materials. Heat speeds flow; cuts loading time.

ENGINEERING RECOMMENDATION — Ask for a copy of new catalog 215B on "Barco Flexible Ball Joints for Piping."

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BARCO MANUFACTURING CO.
5421 Hough Street, Barrington, Illinois
The Only Truly Complete Line of Flexible Ball, Swivel, Swing and Rotary Joints
In Canada: The Holden Co., Ltd., Montreal

Happenings . . .

caused by conventional fuels."

"This new fuel could make possible the same sort of revolution in jet engine performance and mechanical development that took place in automobiles through the introduction of high-octane gasoline. The reason for this is that present jet engines have not been designed to take full advantage of the new low-luminosity fuel. Jet fuels in the future will be rated by luminometer number, or "L.N.", which may well open up a numbers race in jet fuels very similar to the octane race in the automotive industry."

"A jet fuel is given an L.N. rating according to how little radiant heat it gives off during burning. The higher the luminometer number the lower the radiant heat and the more desirable the fuel. Most jet fuels now have an L.N. rating of between 45 and 65, whereas the new Texaco fuels are rated from 135 and up. Kemp stated that almost simultaneously with the discovery and development of luminometer ratings, Texaco had devised methods to manufacture high L.N. fuels in commercial quanities. Jet engine tests using over 1 million gallons of the fuel have been carried out by major aircraft engine manufacturers as well as in Texaco's own jet engine laboratories, he said.

Operation Fuel Switch To Continue This Winter

The oil industry has reactivated and will continue its participation in the "Operation Fuel Switch" program this winter as part of the industry's voluntary plan to cooperate with the Air Pollution Control District.

Operation Fuel Switch went into effect September 30, and will continue through May 1, 1960. During this period refineries will burn only natural gas when eye irritation is anticipated.

The announcement was made in a letter from Felix Chappellet, vice president and general manager of the Western Oil and Gas Association, to S. Smith Griswold, air pollution control officer.

Possible Hike in Gasoline TEL Content May Be Ahead

The lead content of gasoline could be raised to a new level of four cubic centimers per gallon and "such change would not significantly increase the hazard to public health," if certain precautionary measures are taken, according to a committee of advisors whose views were made public by Dr. Leroy E. Burney, surgeon general of the Public Health Service.

In releasing the committee's views, Burney emphasized that the Public Health Service has no legal authority to control the lead content in gasoline.

He said, "The committee's findings should not be interpreted as a regulation of the Public Health Service or as an agreement with the industry. If industry

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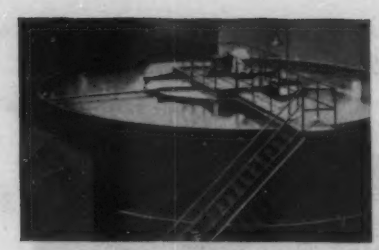

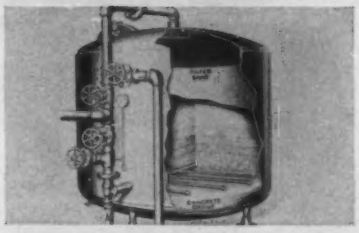

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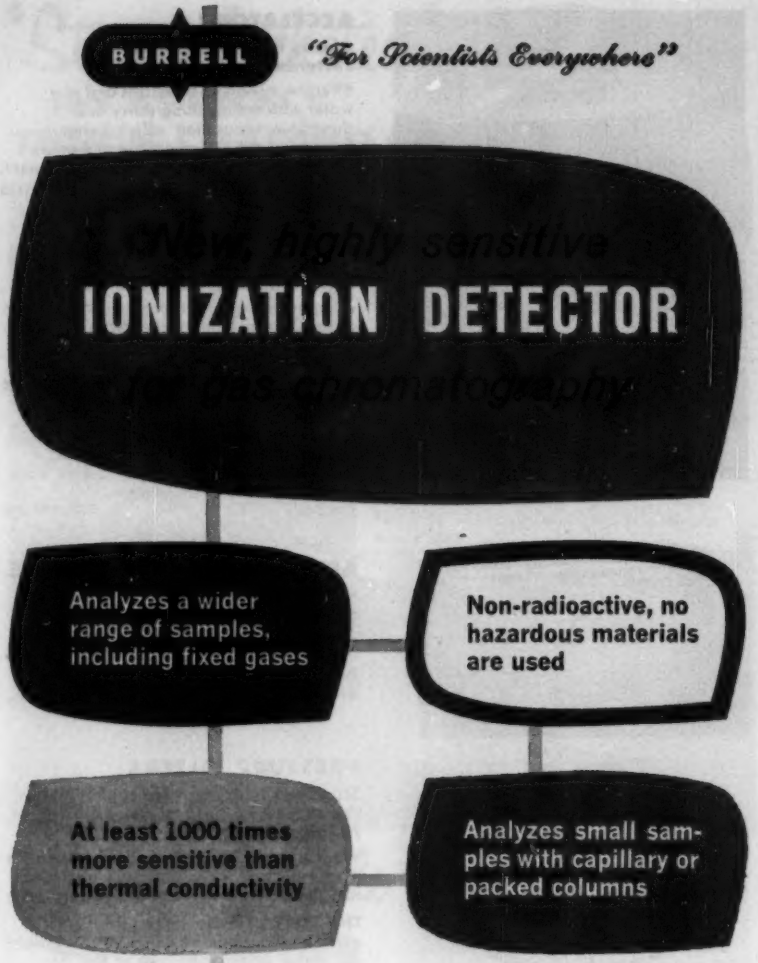
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Happenings . . .

does increase the tetraethyl lead content, however, I urge that they take the precautionary measures outlined by the committee."

The committee concluded that a change in the concentration from the present maximum of three cc to a new maximum of four cc per gallon of gasoline would not increase the hazard involved in the manufacture and distribution of leaded gasoline. It also concluded that available data do not indicate that such a change would significantly increase the hazard to public health from the greater lead discharge from auto exhausts into the community atmosphere.

Cooling Tower Institute Transfers Its Offices

The Cooling Tower Institute, has transferred association offices from Palo Alto, Calif., to Houston. Operation of the CTI programs will continue in the broad areas of research and in the publication of industry standards under the direction of James L. Willa, CTI manager, with offices at 1120 West 43rd St., Houston 18, Texas. Willa is taking over the administrative operation of the association after 8 years as field engineer for the national group.

Dow Forms New Lab Group To Deal With Plastics

The Dow Chemical Co. has formed a new laboratory group, the Long Range Plastics Application Laboratory, to concentrate on the physical and mechanical manipulation of plastics. Its activities will be mainly problem-oriented rather than centered on specific plastic materials, according to Dow. It will tackle long-range application problems and develop new and simplified methods of fabricating plastics. The laboratory will be headed by Douglas S. Chisholm at Dow headquarters, Midland, Mich.

API's 1959 Meet Scheduled For November 9-11

Leaders in the field of business, industry, education, and government are included among speakers to be heard at the 39th Annual Meeting of the American Petroleum Institute, November 9-11, 1959, in Chicago.

The activity-packed program in the Conrad Hilton, Palmer House, and Congress Hotels will unfold before a colorful backdrop of exhibits marking the 100th anniversary of the American oil industry.

More than 6,000 oilmen from throughout the United States and abroad are expected to attend the three-day conclave, an event which has become the

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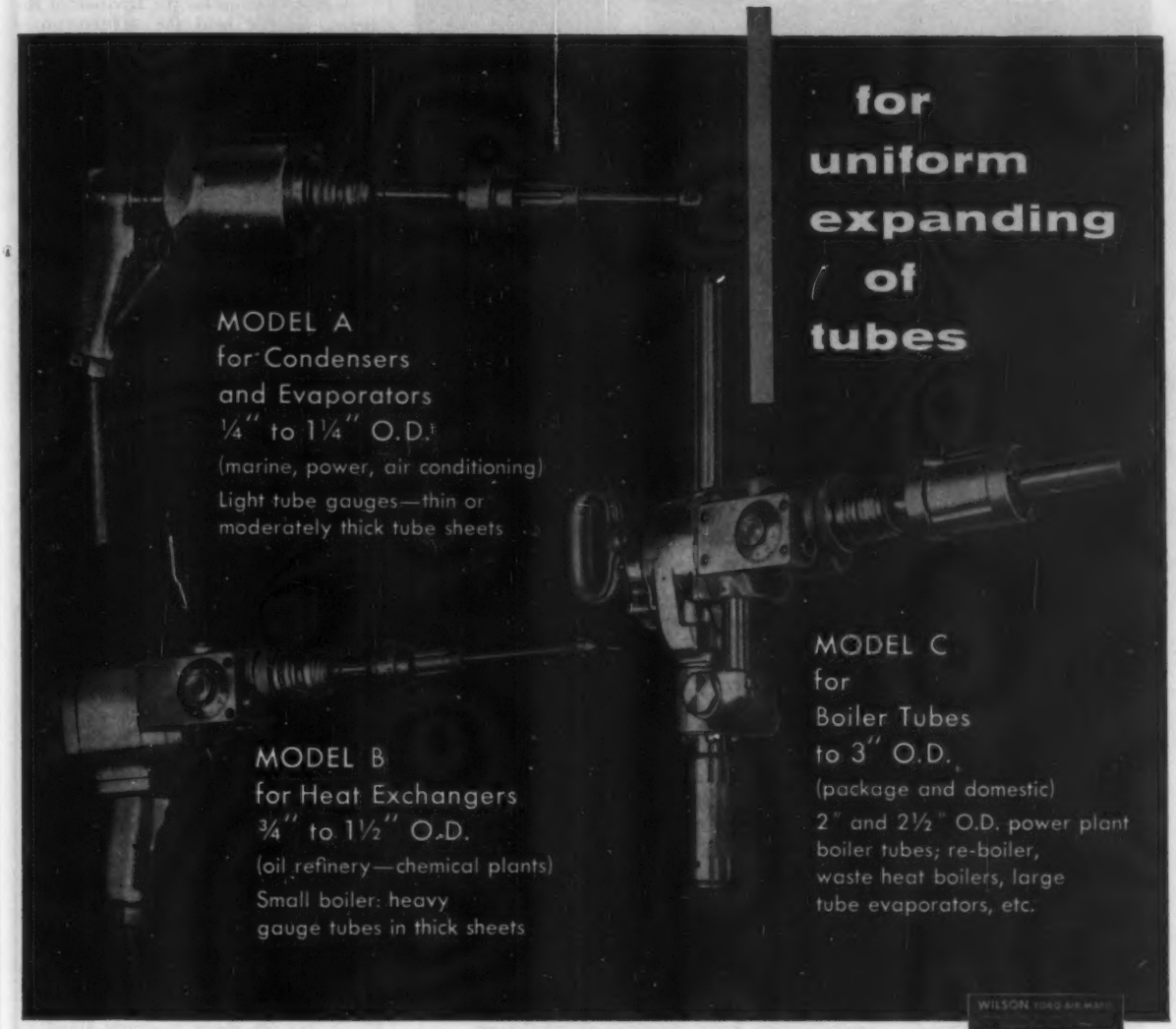
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Happenings . . .

largest annual meeting on the oil calendar.

Group and general sessions will again be telescoped into two and one-half days, so that Wednesday afternoon will be reserved exclusively for board, committee, and subcommittee meetings.

A group session for the Division of Refining will be held the afternoon of November 9 and the morning of November 10. General sessions will also be held the afternoon of November 9 and morning of November 10. An additional general session will be held the morning of November 11.

Scheduled to speak at the general sessions are Hon. J. Howard Edmondson, governor of the state of Oklahoma; C. H. Greenewalt, president of E. I. du Pont de Nemours and Co., Inc., Wilmington, Del.; Donald David, chairman of the Committee for Economic Development, New York; and Frank M. Porter, president American Petroleum Institute. H. S. M. Burns, president Shell Oil Co., New York, and chairman of the API Board of Directors, will preside at the two general sessions.

Included in the list of prominent figures in industry, business, education, and government scheduled to address group sessions are: B. L. Majewski, president, Great American Oil Co., Chicago, Ill.; Donald K. Russell, financial analyst, Lehman Corp., New York; Kenneth W. Mc-

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The booklet is written to help authors organize and develop their ideas for books to the point where they can obtain the support and backing of a publisher. It answers many questions about the author-publisher relationship, and presents many practical checklists for preparing material for publication.

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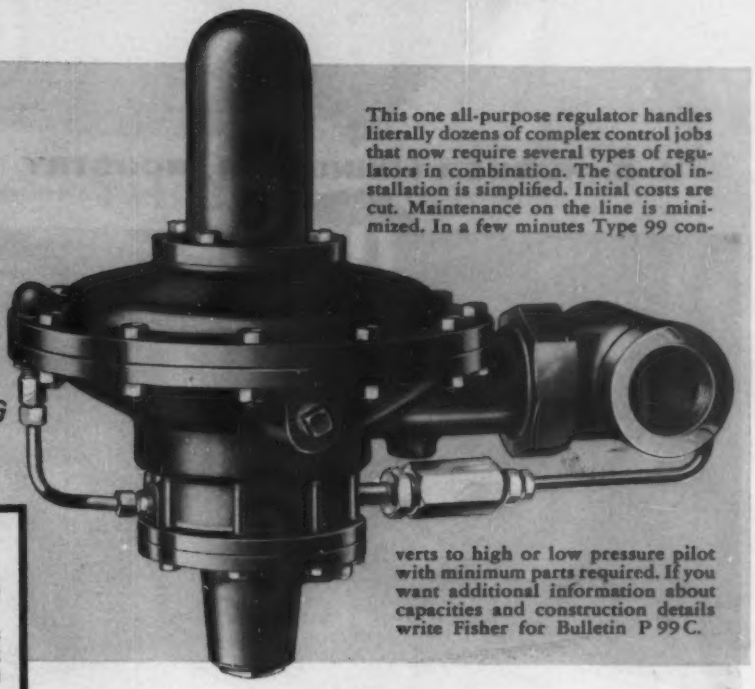

This one all-purpose regulator handles literally dozens of complex control jobs that now require several types of regulators in combination. The control installation is simplified. Initial costs are cut. Maintenance on the line is minimized. In a few minutes Type 99 converts to high or low pressure pilot with minimum parts required. If you want additional information about capacities and construction details write Fisher for Bulletin P 99C.

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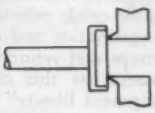
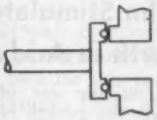
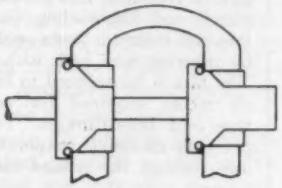


⅛" Composition Disc Single Port. Max. Inlet 250 psi. 1⅛" Composition Disc Single Port. Max. Inlet 150 psi.



⅛" "O" Ring Single Port. Max. Differential 250 psi. 1⅛" "O" Ring Single Port. Max. Differential 250 psi. (with heavy main spring) 2" "O" Ring Single Port. Max. Differential 40 psi.



2" "O" Ring Double Port. Max. Differential 100 psi.

1. **The factory pre-set spring provides powerful lock-off action.**
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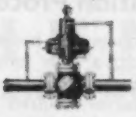
5. **Composition valve disc assures tight shutoff on zero flow and excellent regulation from low flow to maximum capacity.**



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Avondale now markets and installs U. S. Rubber's "Permobond" Tank Lining . . . a new service to industry. Included in this work are rubber lining process equipment, shafts, miscellaneous weldments, pipe and fittings. A complete vulcanizing plant has been provided with all-new equipment, including a 6′ I.D. x 40′ long steam vulcanizer (center background above). Let Avondale solve your corrosion problems . . . starting today.

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Happenings . . .

Farland, educational consultant, General Motors Corp., Topeka, Kans.; Hon. Oren Harris, United States representative from Arkansas and chairman of the House Committee on Interstate and Foreign Commerce.

Also Hon. T. Keith Glennan, administrator, National Aeronautics and Space Administration, Washington, D. C.; Paul W. McCracken, professor of business conditions, University of Michigan, Ann Arbor, Mich.; Avery C. Adams, chairman and president, Jones and Laughlin Steel Co., Pittsburgh, Pa.; Hon. John H. Williams, commissioner, Atomic Energy Commission, Washington, D. C.; Theodore Shabad, specialist on Russian affairs, Foreign News Section, New York Times, New York; and William F. Butler, vice president, economic research, planning, and development, The Chase Manhattan Bank, New York.

The general sessions and all group sessions, with the exception of the Transportation and Marketing divisions, will be conducted in the Conrad Hilton Hotel.

Computer Conference To Be In Tulsa, December 1-2

The oil industry's second Computer Conference for refiners will be conducted at the Hotel Tulsa in Tulsa, December 1-2. The conference, sponsored by WPRA, will consist of formal papers, panels and informative work-shop groups. Topics will include crude selection, gasoline blending, organization and operation of computer groups and refinery simulation. An innovation at this conference will be an "equipment library" in which computer manufacturers will display data on their equipment.

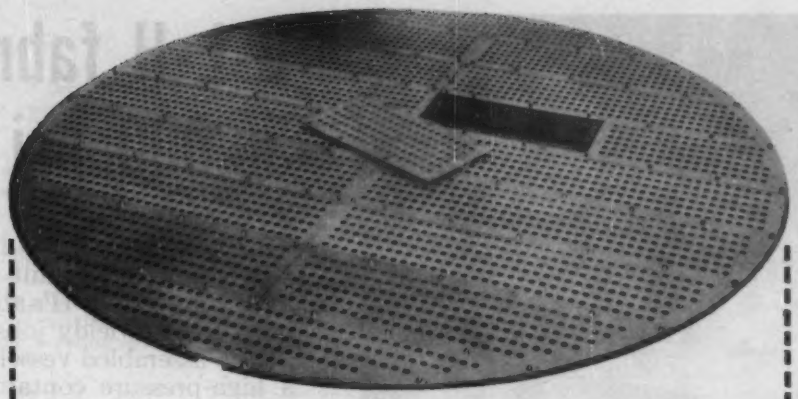
Asphalt Film Stimulates Grass Growth in Arid Areas

Experiments on the use of asphalt film to stimulate the growth of grass in arid areas and alleviate dust bowl conditions have been reported by Dr. William J. Sweeney, vice president, Esso Research and Engineering Co. He reports that soil moisture losses could be reduced by covering seed beds with asphalt film. The film is formulated to last the five or six weeks required for seed germination and breakthrough. The technique prevents excessive evaporation of moisture through the ground surface.

UOP Licenses New Catalytic Hydrodealkylation Process

Universal Oil Products Co. has made available for licensing, a new catalytic hydrodealkylation process trade named Hydeal. The new process resulted from research, development and engineering efforts of both Ashland Oil and Refining Co. and UOP. The Hydeal process ini-

For more data on advertised products, use Readers' Service Cards, last page.



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An electronic computer now assures you of maximum process performance from Hendrick Perforating Trays. That's because this computer takes your design figures and combines them with carefully developed Hendrick formulas. The result is a set of specifications that exactly match your design requirements.

The specifications actually give you greater efficiency and at lower initial cost. You get higher vapor thru-put, less entrainment. You get a wide range of stable operation. Maintenance is easier. Tower construction is simpler. *And*...you save in the diameter of columns required for a specified process capacity.

Available in all types of commercially rolled metals. Stainless steel or other corrosion-resistant metals are recommended for corrosive services. As a result, you can now cut replacement costs and production losses caused by downtime, changeovers or cleaning.

Hendrick engineers will be happy to work with you in preparing Perforated Trays for use in your process equipment. Just clip the coupon for full information.

Hendrick is licensed to manufacture ESSO "Jet-Trays," SOCONY "Uniflux," SHELL "Turbo-Grid" and STONE and WEBSTER "Ripple" Trays. Hendrick is also equipped to supply all types of trays to specifications.

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For more data on advertised products, use Readers' Service Cards, last page.

B-L-H fabricates 30,000 psi vessel

This pressure vessel—believed to be the largest ever built—is one more indication of B-L-H's ability to handle huge and unwieldy jobs efficiently.

The assembled vessel, consisting of a high-pressure container moving in and out of a rigid frame made of six laminated steel plates each 4 in. thick, weighs 474,000 lb. and stands 35 ft. 1¼ in. high.

Designed by B-L-H's Loewy-Hydropress Division for the United States government, this unusual piece of equipment was built to withstand the tremendous operational pressure of 30,000 psi and a test pressure of 45,000 psi. The super-strength bronze sealing retaining rings so essential to successful performance under these extreme pressures were manufactured and machined in the Eddystone Division foundry.

Testing of this vessel, also done at Eddystone, required an elaborate procedure comparable in precision to the observation of a patient's heart during a surgical operation. More than 80 SR-4® strain gages, products of B-L-H's E&I Division, were located at all critical points of the structure. Over 1500 readings were taken of the strains and stresses developed during loading the vessel up to 45,000 psi and down again. Evaluation of all test results and a full year of normal operation proved that the numerous parts and materials behaved even better than anticipated.

Our illustrated Weldment Bulletin 7001 will give you an excellent idea of our vast fabricating facilities. A copy is yours for the asking.

View of high-pressure vessel fabricated at Eddystone showing pressure cylinder withdrawn for loading

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Hydraulic turbines • Weldments • Dump cars • Nonferrous castings • Diesel engines • Special machinery • Bending rolls • Ship propellers

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Happenings . . .

tially may be installed for the production of benzene from lower value heavier aromatics.

By use of Hydeal, refiners, chemical manufacturers and coke oven operators can produce, for chemical use, benzene from such feed stocks as toluene, xylenes and heavier aromatic mixtures, UOP engineers said. The process may also be applied for the manufacture of phenol and naphthalene from higher boiling substituted phenols and alkylanaphthalenes. UOP will handle licensing details for the new process.

Apparatus Analyzes Ozone Content of Atmosphere

An apparatus for analyzing the ozone content of the atmosphere has been patented by API as part of its continuing research into the problem of air pollution.

Ozone is a faintly blue gaseous form of oxygen. Its normal concentration in air is low, but some communities having air pollution problems have suspected that larger proportions of ozone are present when air pollution accompanies so-called smog (smoke and fog) conditions. The API apparatus is designed to help measure ozone concentration.

As with all patents that grow out of research projects financed by the API, the ozone apparatus is dedicated to the "full, free and unrestricted use of the public." Filing and suit of the patent application was handled by the Patent Department of Standard Oil Co. (Indiana). The inventor is listed as Francois J. Olmer, Highland Park, Ill.

Standard of Indiana to Build New Marine Terminal

Standard Oil Co. (Indiana) will begin construction of a marine terminal on the Missouri River near Jefferson City, Mo., before the end of 1959. To be located on a 60-acre site about four miles northwest of Jefferson City, it is scheduled for completion and initial operation in May,1960.

Facilities will include a barge unloading dock, four storage tanks with a total capacity of 142,000 barrels, and a truck transport loading dock. The terminal will serve an area within a radius of about 70 miles with gasolines, furnace oil, and heater oil. Products will be supplied from the company's Wood River, Ill., refinery.

Magnolia-Mobil Merger Completed September 30

Magnolia Petroleum Co. officially merged with Socony Mobil Oil Co., Inc., September 30. Necessary legal documents have been filed in New York and Texas. The merger of Magnolia is the first step in the new coast-to-coast Mobile coordination (see PETROLEUM REFINER, September issue, page 381). General Petroleum and Mobil Producing will be merged about January 1, 1960.

- Changing Times -

Merger discussions between Tidewater and Skelly Oil are called off because of "unfavorable market conditions." **Similar plans of Texaco and Superior Oil abandoned** because of pressure from Justice Department.

New company, **Amoco Fina S.A. formed by Amoco Chemicals. Firm will manufacture and market additives** for petroleum products. Registration papers have been filed in Belgium.

Magnolia Building in Dallas becomes "Mobil Building" to coincide with Magnolia's becoming part of new Mobil organization.

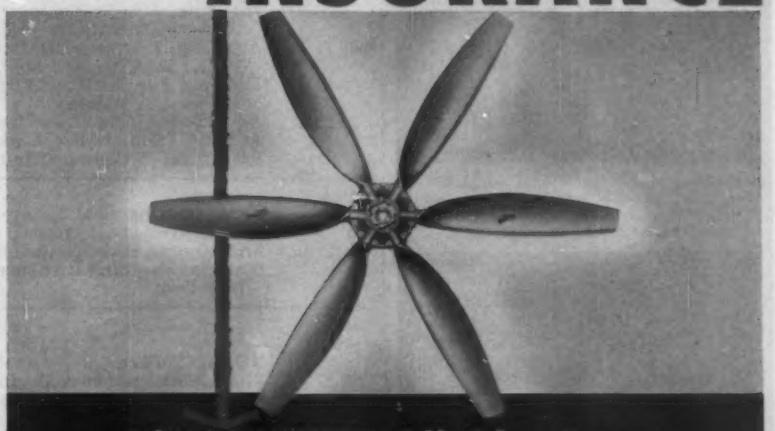
UOP's McCook, Ill., plant and service lab logs 1 million man-hours without lost time accident since December 1956.

Amoco Chemicals obtains new contract for manufacture of jet starter cartridges from Air Force to be used in F105 Jet. Cartridges replace bulky ground starting equipment-utilize propellant similar to type used in low-temperature gas generators.

Refining profits are up for second quarter of 1959. Total of $621 million was reported, an increase of $118 million compared with same quarter a year ago.

Bureau of Mines forecasts October gasoline demand of 4.125 million bpd, gasoline yield of 44.9 percent and total crude runs of 7.65 million bpd.

ENDURANCE INSURANCE



with HARTZELL All-Aluminum Adjustable Pitch Fans

Hartzell all-aluminum heat exchanger and cooling tower fans last and last and last under the most severe operating conditions. On hundreds of installations these fans operate continuously, moving great volumes of air to provide efficient, dependable performance.

• Hubs and blades are durable, high strength aluminum alloy that provides exceptional resistance to corrosion. • Blade shanks are threaded to fit threaded blade housings cast into hub. • Blades may be turned to change pitch by merely loosening two bolts. • **Because all hubs are dynamically balanced and all blades balanced against a master blade, damaged blades may be replaced in the field without destroying the balance of the assembly.** • Eleven sizes, 40" to 132" diameters; 3, 4 and 6 blade assemblies.

Ask your Hartzell Field Engineer for complete details or write direct for Bulletin A-111B.

Other famous Hartzell products include industrial fans and blowers, controllable and full feathering propellers for light aircraft, crop drying equipment, and farm ventilating fans.

HARTZELL PROPELLER FAN CO.

Engineering Offices in Principal Cities

Div. of Castle Hills Corp. Piqua, Ohio

BRANSON

Ultrasonics at work . . .

CORROSION SURVEYS and FLAW DETECTION

AUDIGAGE® 6 — the new miniaturized, self-powered "mighty midget" Thickness Gage and Flaw Detector. Ideal for corrosion surveys by one man in awkward locations. Weighs less than 5 pounds complete. Uses new high-sensitivity, high-resolution **Type Z** transducers, flat or curved, in various mounts for every application. Measures directly in inches between 0.09" and 5.0". **BULLETIN A-201.**

AUDIGAGE® 5 — the standard self-powered instrument for field corrosion surveys when greater range or accuracy than Model 6 are required. **BULLETIN A-2.**

VIDIGAGE® 14 — the high-accuracy, high-speed, ultra-sensitive gage with a 14" CR tube. Range 0.005" to 2.7" with accuracies to 1/10 of 1%. Interchangeable oscillators and direct-reading scales. Extension cables and intercom phones for remote testing up to one-fifth mile from the basic instrument. **BULLETIN V-200.**

SONORAY® 5—the new portable, high-performance pulse-echo Flaw Detector for testing weldments, shafts, plates, etc., and detecting other internal flaws. Only 37 lbs., 7½" x 11" x 20¼" long. **BULLETIN T-203.**

Send Coupon to **BRANSON INSTRUMENTS, INC.**
54 Brown House Road, Stamford, Connecticut

BRANSON: Send Bulletin **A-201, A-2, V-200, T-203.**

NAME_____

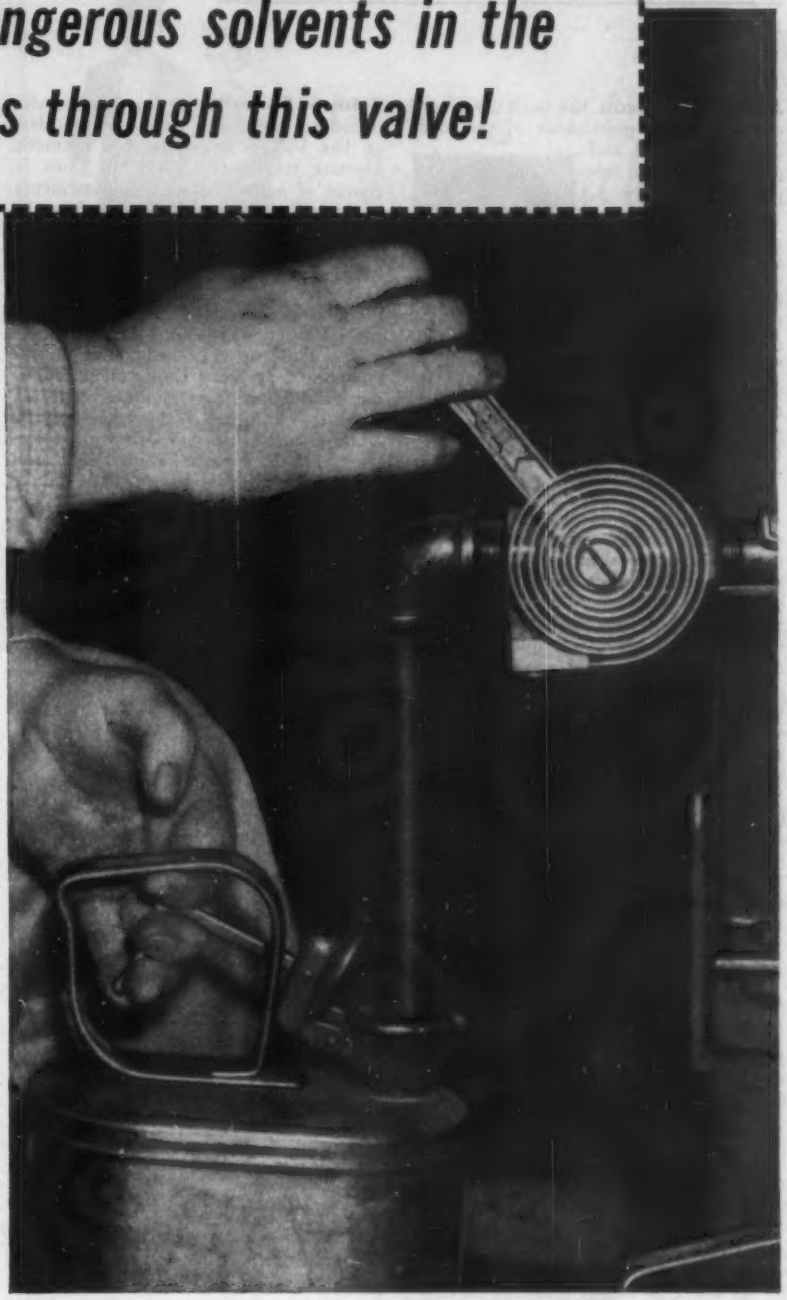
FIRM_____ DEPT._____

ADDRESS_____

Meetings Calendar

Oct.	
20–22	**American Standards Association,** National Conference on Standards, Sheraton-Cadillac Hotel, Detroit.
20–22	**American Society of Mechanical Engineers-American Society of Lubricating Engineers,** Lubrication Conference, Sheraton-McAlphin, New York.
20–22	**National Association of Corrosion Engineers,** North Central Region Conference, Cleveland.
23	**Natural Gasoline Association of America,** Southern Regional Meeting, Carlton Hotel, Tyler, Texas.
25–27	**Independent Petroleum Association of America,** Annual Meeting, Statler-Hilton Hotel, Dallas.
26–28	**National Lubricating Grease Institute,** Annual Meeting, Roosevelt Hotel. New Orleans.
27	**American Institute of Chemical Engineers,** Annual Meeting and Engineering Symposium, New York Section, Hotel New Yorker.
28–29	**Computer Applications Symposium,** Morrison Hotel, Chicago.
28–29	**Western Petroleum Refiners Association,** Question and Answer Session on Refining Technology, Rufus Garrett Hotel, El Dorado, Ark.
28–30	**Society of Automotive Engineers,** National Fuels and Lubricants Meeting, La Salle Hotel, Chicago.
30	**AIChE,** South Texas Section Technical Meeting, Moody Center, Galveston, Texas.
Nov.	
4– 6	**Institute of Radio Engineers,** National Automatic Control Conference, Sheraton Hotel, Dallas.
9–11	**American Petroleum Institute,** Annual Meeting, Conrad Hilton, Palmer House, and Congress Hotels, Chicago.
11–13	**National Fire Protection Association,** Fall Conference, Hotel Fort Des Moines, Des Moines.
20	**NGAA,** Panhandle-Plains Regional Meeting, Herring Hotel, Amarillo.
29-Dec4	**ASME,** Annual Meeting, Chalfonte Haddon Hall, Atlantic City.
30-Dec4	**Exposition of Chemical Industries,** New York Coliseum.
Dec.	
3– 5	**American Chemical Society,** Southwest Regional Meeting, Baton Rouge.
6– 9	**AIChE,** West Coast Meeting, Sheraton Palace Hotel, San Francisco.
11–15	**SAE** Meeting, Sheraton-Cadillac and Statler Hotels, Detroit.
13–16	**Material Handling Institute,** Annual Meeting, Savoy-Hilton Hotel, New York.
Jan. 1960	
22	**NGAA,** Gulf Coast Regional Meeting, Robert Driscoll Hotel, Corpus Christi.
25–28	**Plant Maintenance & Engineering Show,** Convention Hall Philadelphia.
31-Feb5	**American Society for Testing Materials,** Committee D-2 Meeting, Statler Hotel, Detroit.
Feb.	
1–5	**ASTM,** Committee Week, Hotel Sherman, Chicago.
21–24	**AIChE** Meeting. Hotel Biltmore, Atlanta.
23–26	**ASME,** Symposium on Thermal Properties of Gases, Liquids and Solids, Purdue University.
26	**NGAA,** Permian Basin Regional Meeting, Lincoln Hotel, Odessa, Texas.
March	
14–18	**NACE,** Annual Meeting, Memorial Auditorium, Dallas
18	**NGAA,** Oklahoma Regional Meeting, Biltmore Hotel, Oklahoma City.
April	
19–21	**Southwestern Gas Measurement Short Course,** Drill Hall, North Campus, University of Oklahoma.
20–22	**National Petroleum Association,** Semiannual Meeting, Hotel Cleveland, Cleveland.
25–29	**American Welding Society,** Annual Meeting and Welding Exposition, Los Angeles.
27–29	**NGAA,** Annual Convention, Rice Hotel, Houston.
May	
2– 6	**API** Midyear Meeting, Safety and Fire Protection Committees, Atlanta-Biltmore Hotel, Atlanta.
9–12	**API** Midyear Meeting, Division of Refining, Statler and Sheraton-Cadillac Hotels, Detroit.
9–13	**American Society for Metals,** Southwestern Metal congress and Exposition, Sheraton and Other Hotels, Dallas.
23–26	**Design Engineering Show,** New York Coliseum.
June	
5–19	**SAE,** Summer Meeting, Edgewater Beach Hotel, Chicago.
19–22	**AIChE,** Meeting, Del Prado Hotel, Mexico City.

The most dangerous solvents in the world pass through this valve!



But it's a *safe* passage. The ROCKWOOD ¾" (Fig. 802) Self-Closing Ball Valve is designed for *smooth, leakproof* handling of highly flammable liquids. A Rockwood Exclusive!

Take a typical installation at an experimental station of one of the nation's largest chemical companies. Here 36 different solvents, ranging from acetone to xylene, are dispensed from bulk containers. All types of self-closing valves were tried and evaluated for this critical job. None equalled ROCKWOOD for positive performance.

Unique ROCKWOOD Full Round Flow design holds turbulence to an absolute minimum — keeps static at a low level. Flash potential is negligible, greatly reducing fire hazard. In addition, the exclusive "*Spring Pressure* Compensation" keeps ball and seat in snug contact — assures leakproof, dripless shut-off, compensates for wear. Bronze valve body and Teflon trim resist corrosion. After 11 months and 103,200 open-and-shut cycles the company reports: trouble-free operation since installation.

Be as safe and sure with your solvent handling. Send coupon for complete details on the ROCKWOOD Self-Closing Ball Valve. Tested and listed by Underwriters' Laboratories, Inc.

ROCKWOOD BALL VALVES

FULL, ROUND FLOW

Distributors in all principal industrial areas

ROCKWOOD SPRINKLER COMPANY
A Division of the Gomewell Company
224 Harlow Street, Worcester 5, Massachusetts

Please send me complete details on the ROCKWOOD ¾" (Fig. 802) Self-Closing Ball Valve.

Name .....
Title .....
Company .....
Street .....
City ..... *Zone* ..... *State* .....

For more data on advertised products, use Readers' Service Cards, last page.

Men In Industry...

Joe T. Dickerson has been appointed executive vice president of the Mid-Continent Oil and Gas Association, effective January 1, 1960. He retires as president of Shell Pipeline Corp. at the end of this year. Dickerson's position is a new one for Mid-Continent and is largely administrative. Although he will maintain headquarters in Washington, his duties will include supervision of the main offices in Tulsa.

Dickerson

Dickerson will direct the assembling and organizing of factual material with reference to the oil and gas industry and make such material available for use by congressmen and their staffs, government officers, editors, columnists, commentators, and reporters. On the basis of such material, he will answer questions concerning the industry. In addition he will give continuous attention to broad basic industry problems in relation to Congress and the Federal Government and will keep the association informed of legislation affecting the industry.

Robert Young has been named Control Laboratory supervisor, Texas Butadiene & Chemical Corp., Channelview, Texas. Formerly a Control Laboratory section head, he joined the company in August 1956, after eight years with E. I. du Pont de Nemours & Co. He holds a degree in chemistry from the University of Houston and is a member of ACS and ASTM.

Donald M. Wreyford, formerly research physicist in manufacturing research has been appointed group leader, Control Laboratory. He came to TB&C in July 1956 from Perkin-Elmer Corp. A physics graduate of Hardin-Simmons University, he is a member of ISA, currently serving on the committee for sampling systems for process analyzers.

C. L. Walker has been promoted to group leader from physicist, Control Laboratory. Formerly with Celanese Corp. for six years, he joined TB&C in November 1956. He is a chemistry graduate of Stephen F. Austin College and is a member of ACS.

Odis Procella has been promoted to group leader. A member of ACS, he is a chemistry graduate of Stephen F. Austin College, and has been with TB&C since August 1957.

Robert E. Parks succeeds Procella. After receiving his chemistry degree from Southwest State College, he was a lab instructor in the Chemistry Department, The University of Texas. He joined TB&C in 1957.

John S. Sprowls has been named vice president and assistant to the president of The Vickers Petroleum Co. Formerly assistant treasurer of Gulf Oil Corp. in charge of loans and related investments, he had direct responsibility for financial negotiations relative to these activities. In his new position he will have direct management responsibilities for long range financing programs and investments and will assist **J. A. Vickers** on special assignments and projects. Sprowls joined Gulf in 1949 as a clerk in the company's Treasury Department following graduation from the University of Pittsburgh with a B.S. degree in business administration. He served in various capacities in the Treasury Department until 1956, when he was charged with the supervision of loans and related investments. In 1953 he received an M.B.A. degree from the University of Pittsburgh.

Ralph M. Knight has been appointed a vice president of U.S. Industrial Chemicals Co. He will direct the Polymer Service Laboratory, coordinate its efforts with other plastics activities within the company, and guide the polyolefin development program. Since joining National Distillers in 1953, Knight has been polyethylene manager, polyethylene production manager, assistant to the vice president for production, and manager of polyolefin planning. He has a B.S. degree in chemical engineering from Newark College of Engineering. From 1939-52, Knight was with the Ammonia and Polychemicals Department, E. I. du Pont de Nemours & Co., Inc., and in 1952-53 he was in the Research Department, Standard Oil Co. (Indiana).

Knight

R. G. Sanders has been named general manager of Southwestern manufacturing for Mobil Oil Co. He is presently a director of Magnolia Petroleum Co. and vice president in charge of refining. Sanders will headquarter in Beaumont, site of Magnolia's refinery, of which he took charge in May 1957. He began his career with Magnolia in 1920 when he joined the refinery's Engineering Department upon graduation from Georgia Tech as an electrical engineer.

He was named chief engineer of the refinery in 1928, and in 1936 was promoted to executive assistant. He became assistant manager of the Refining Division in January 1938.

William Leonard Swearngin has been appointed manager of supply, Texas Natural Gasoline Corp. He will have charge of procuring natural gas liquids and product exchanges for the corporation. Before joining Texas Natural, Swearngin was with Phillips Petroleum Co. as a buyer in the Natural Gas Liquids Department. Prior to that he was sales engineer for Texas and Southeast New Mexico with Reda Pump Co., and before that spent 16 years with McNally Pittsburgh Manufacturing Corp. as chief estimator and sales engineer. Swearngin attended Pittsburgh State University, receiving a B.S. degree in mechanical engineering.

Basil R. Littin has been named associate director of public affairs for Continental Oil Co. He will headquarter in Washington, serving as manager of the company's Washington office and as assistant to **Harold S. Skinner,** Houston, who is director of public affairs for Continental. Littin resigned his position with Hill and Knowlton, Inc., public relations counseling firm of New York. He had been for a member of years an account executive on numerous industrial accounts both in Washington and New York, and had been manager of the Hill and Knowlton Washington office.

Howard A. Parker, Jr., assistant to the general manager of manufacturing for American Oil Co., is being transferred to Chicago to join Standard Oil Co. (Indiana). He was named manager of coordination and supply planning in the Supply and Transportation Department. A 1944 graduate of Cornell University, he joined Standard as a process design engineer in the Research and Development Laboratories, Whiting, Ind., in 1944. He later served as technical director at the Destrehan, La., refinery and moved to the New York general office of American Oil in 1956.

Henry P. Wheeler, Jr., Silver Spring, Md., has been named an assistant director of the Bureau of Mines to administer helium activities, succeeding **Dr. Clifford W. Seibel,** who has retired. **Paul V. Mullins,** formerly chief of helium operations, becomes general manager, helium operations, Amarillo, Texas. He will head field operations at five government plants in Amarillo and Exell, Texas; Otis, Kan.; Shiprock, N. M.; and Keyes, Okla.

Wheeler

As the Bureau's new assistant director for helium, Wheeler assumes responsibility for a program involving the opera-

Men . . .

tion of plants capable of producing some 600 MMcf of helium a year for defense and industry.

C. P. Lattin, Jr., formerly vice president in charge of Foster Wheeler Corp.'s Process Plants Division, has been appointed general manager of sales. **B. L. Denker,** previously manager of the Contract Operations Department will become general manager, Process Plants Division. **W. B. Hudson,** manager of the Proposal and Process Engineering Department, will become general manager of foreign operations. In this post he will coordinate the activities of the company's foreign subsidiaries and facilities.

Verne L. Snow has been elected a vice president of The Refinery Engineering Co., Tulsa. He will continue as manager of Treco's Four Corners Division, located in Farmington, N. M., a post he has held since shortly after the division was formed in early 1958. Snow holds a mechanical engineering degree with a petroleum option from Oklahoma State University. He has been with Treco since 1950, serving variously as field engineer, project manager, estimator, construction superintendent and general construction superintendent before moving to Farmington.

Snow

John A. Parsons has been named a vice president of American Plastics Corp. Named to equal posts are **J. William Arpin** and **Elmer G. Smith.** Parsons, named the executive vice president of American Plastics, has served as director and vice president in charge of production. Formerly assistant plant manager, Arpin has been appointed vice president for engineering and development. Prior to joining American Plastics, he was vice president of Arpin Products, Inc., Orange, N. J., and previously held management posts in other molding companies. Smith was previously company sales manager. He has spent 15 years with Heyden Newport Chemical Corp. in various sales, development and production functions.

Milliard G. Howland was named plant manager of the Bainbridge, N. J., facilities. He has been with the company since 1940.

Don M. Shields, Sunray Mid-Continent Oil Co.'s former manager of crude oil purchases and sales, has been named general manager of domestic crude oil purchases and sales. The division will be responsible for supplying domestic crude oil for DX Sunray's two Oklahoma refineries. It also will arrange for the sale and exchange of crude oil and will provide a market for all Sunray Mid-Continent domestic production.

Marvin C. Jones, previously manager

"Traveling in the Best of Circles"

Your product will be "traveling in the best of circles" when you use HELIFLOW® EXCHANGERS.

Heliflow® rates high in the blue book of heat transfer society—truly a thoroughbred—or, more appropriately, we might say a "bearcat" when it comes to doing your job.

High rates of heat transfer, a cinch to clean—and just like old Uncle Remus—dependable. When it comes to pushing BTUs around you just can't beat Heliflow.

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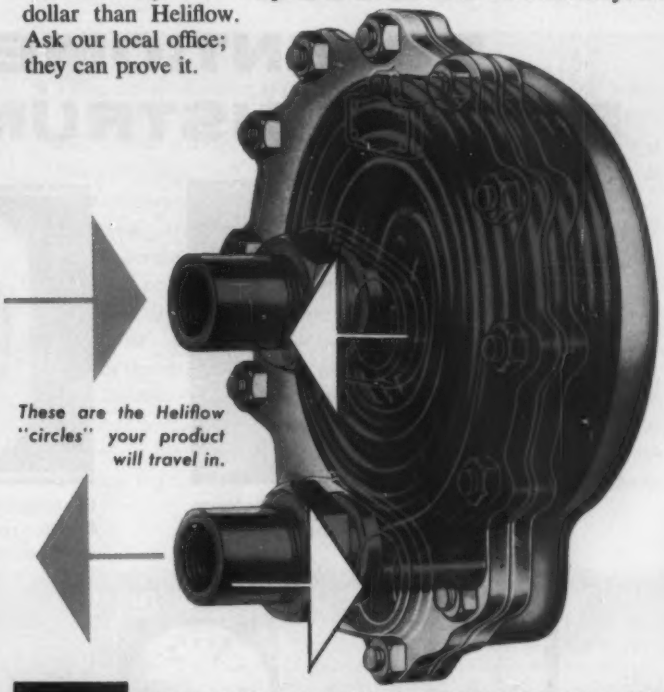
Seriously, though, we defy you to find any exchanger on the market today that is packed with more BTUs for your dollar than Heliflow.
Ask our local office; they can prove it.



These are the Heliflow "circles" your product will travel in.

GRAHAM MANUFACTURING CO., INC.
Heliflow Corporation
170 GREAT NECK ROAD, GREAT NECK, N. Y.
Offices in principal cities and Canada

Factory: Batavia, N.Y. Other Graham precision-built products: Steam Jet Ejectors, Monobolt Heat Exchangers, Deaerating Heaters, Surface and Barometric Condensers, Steam Vacuum Refrigeration, Aquamizer Evaporative Condensers.

For more data on advertised products, use Readers' Service Cards, last page.

Bristol Dynamaster* Electronic Instruments have proved themselves in thousands of installations. They fully meet today's most exacting standards of accuracy and dependability. They measure almost any variable that can be translated into an electrical quantity (d-c current, d-c voltage, resistance or capacitance). Just a few are: temperature, pH, speed, voltage, smoke density and strain.

Here are some outstanding features that make them ideal for industrial plants, pilot plants, and for research, test, and laboratory use:

1. Continuous standardization—eliminates standardizing mechanism and dry cell—no interruption to control. **But retains precision standard cell for highest accuracy and stability.**

2. Simple design—few moving parts.

3. Easy to use and service—little or no maintenance required.

4. Rugged construction—unaffected by vibration.

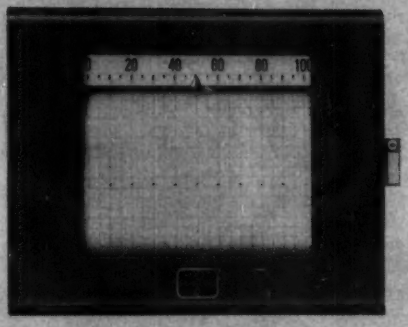
MODELS FOR EVERY PURPOSE. Dynamaster Instruments are now available as:

A. Single-pen, two-pen, and multiple-record (up to 24 points) strip-chart instruments.
B. One- and two-pen round-chart recorders.
C. High-speed recorders (0.4 second).
D. X-Y recorders.
E. Extended range recorders.
F. Adjustable span and zero recorders.
G. Miniature 3-inch strip-chart recorders.
H. Electric controllers in both strip- and round-chart models—all types of control action and as time-program control.
I. Pneumatic controllers in both strip- and round-chart models—all types of control action and time-program control.
J. Instruments for electronic measurement—pneumatic transmission of reading by 3-15 psi signal.
K. Round chart program controllers.
L. Telemetering transmitters.
M. Drum-type precision indicators.
N. Multi-bank recorder—will accept up to 200 separate inputs and record them on 12-inch wide strip chart.
O. Relay-rack mounting models—most models available in case that fits standard 19" relay-rack without modification to instrument or rack, without panel-cutting or masking.

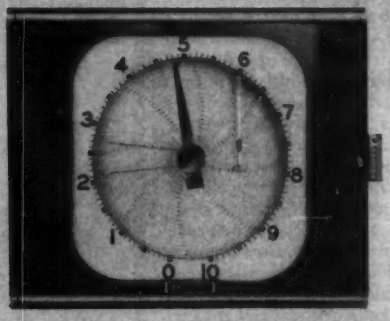
Bristol Dynamaster Potentiometer and Bridge Instruments can be equipped with analog-to-digital encoders of various types for digital readout and computer use. For complete details, write for Bulletins P1245A, P1270, P1271, P1242, and P1282. The Bristol Company, 111 Bristol Road, Waterbury 20, Conn. o.e *T. M. Reg. U. S. Pat. Off.

look to Bristol for the complete line of

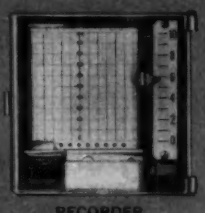
ELECTRONIC POTENTIOMETER and BRIDGE INSTRUMENTS



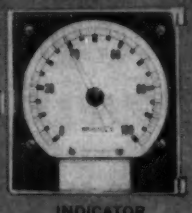
Dynamaster* Electronic Potentiometer or Bridge—records on 11-inch, 120-foot-long strip chart.



Dynamaster* Electronic Potentiometer or Bridge—records on 12-inch round chart, indicates on extra-large scale.



RECORDER



INDICATOR

Plug-in Miniature Electronic Dynamaster Potentiometer and Bridge instruments—Only 5" x 5⅛" panel dimensions; ideal for graphic panel instrumentation.

BRISTOL

TRAIL-BLAZERS IN PROCESS AUTOMATION

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

Men . . .

of crude oil traffic for Mid-Continent Pipe Line Co., has been named manager of foreign crude oil purchases and sales. This division will obtain markets for foreign-produced crude, and will handle the company's imports program.

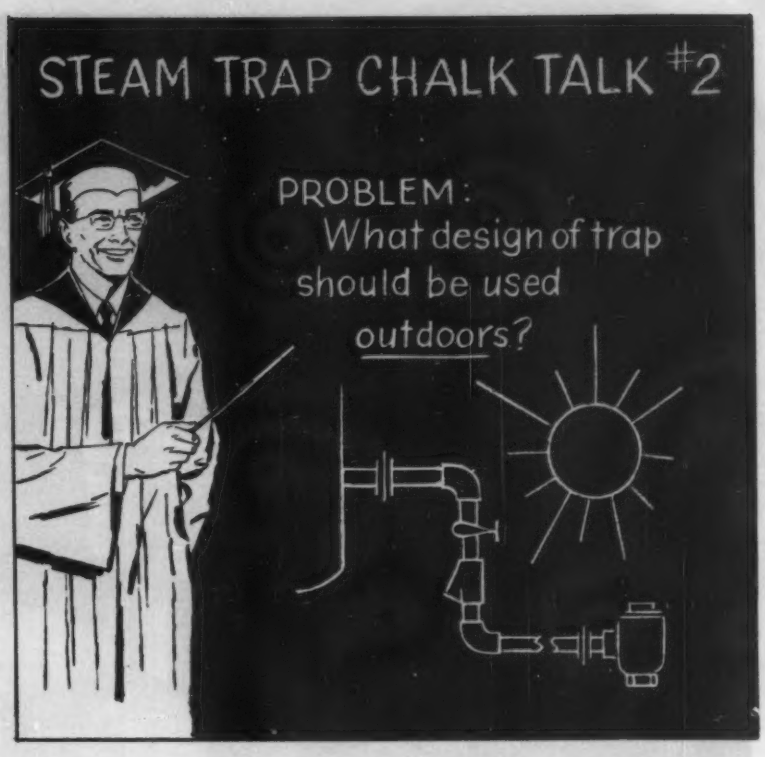
J. W. Hawkins, former manager of planning and development for Mid-Continent Pipe Line, has been named manager of economics and coordination and will serve in an advisory capacity to provide cost analyses, economic evaluations, long-range forecasting and planning, computer applications and other activities.

John W. Hackney has joined Beaco, Ltd. of Canada as vice president for process plant projects. In this capacity he will be responsible for the engineering and construction of chemical, hydrocarbons and other process industry projects. Hackney is a graduate of Carnegie Institute of Technology, with M.S. and professional degrees in civil engineering. For the past 24 years he has been with Aluminum Company of America and Diamond Alkali Co. in the design and construction of electrolytic reduction, alumina, hydro-electric, chlorine-caustic, silicate, chlorinated-hydrocarbon, chromate and other production facilities. His most recent assignment has been as manager of construction and cost engineering for the Diamond Alkali.

Hackney

Charles H. Bennett, supervisor of the fluid coking area at Tidewater Oil Co.'s Delaware refinery, is attending the 1959 College Executive Training Course being conducted at the University of Pittsburgh from September 28 to November 20. Bennett joined Tidewater in February 1948 as a design engineer at the company's former Bayonne refinery and, in

Use Readers' Service Postcard on page 345 for More Information on Advertised Products



- First, use Anderson Quik-Flex thermostatically designed steam traps. These traps have no pockets in which water will collect and freeze. An open pipe on the discharge side provides constant drainage and eliminates any maintenance during freezing temperatures.

Second, use a cooling leg of at least three feet. Thermostatic traps operate on temperature differential, and sufficient piping must be provided for the condensate to cool.

Third, install the strainer in a down position. Strainers in horizontal positions collect condensate which freezes and breaks the strainer body during cold weather.

Anderson Quik-Flex Steam Traps are built especially for outdoor service. Guaranteed freeze-proof for two years, they provide a lifetime of trouble-free, freeze-proof draining of condensate from steam lines. Mail coupon for complete details.

A TRAP FOR EVERY PURPOSE

THE V. D. ANDERSON COMPANY
division of International Basic Economy Corporation
1953 West 96th Street • Cleveland 2, Ohio

Please send without obligation your catalog describing Anderson freeze-proof Quik-Flex Thermostatic Steam Traps.

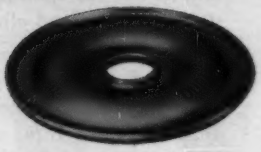
Name_____ Title_____
Company_____
Address_____
City_____ Zone_____ State_____

ANDERSON **QUIK-FLEX**

For more data on advertised products, use Readers' Service Cards, last page.

Pencil test demonstrates how the DURABLA valve member tilts and opens easily, without noticeable friction. Compare this with any other pump valve.

NO. 1 REASON



this is the ideal valve for high-speed pumps

Key to the high efficiency and free action of a DURABLA V-7* Pump Valve Unit is the patented lightweight valve member. Making only "point contact" on the sleeve, it can't bind or hang up. Nor can it warp, thanks to its unique arched design.

This low-lift valve member is designed to open with a tilt, following the flow lines. Valve action is very sharp, thanks to lightness and flexibility. That's why DURABLA is the only valve ideally suited to high-speed operation.

DURABLA valve units operate freely under temperature-pressure extremes, with corrosive fluids and in any position. Available in 17 sizes, they will meet over 300 variations in installation requirements.

Send for booklet PE 109.

DURABLA MANUFACTURING COMPANY

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DM-35

*Patent applied for

DURABLA®

Manufacturers of DURABLA sheet packing, gaskets and check valves

Men . . .

1955, was assigned to planning details of the company's Delaware refinery. From 1956 to earlier this year, he served as technical foreman on the catalytic cracking unit, technical foreman of the fluid coker, and staff assistant to the refinery manager. He was named to his present post in July.

H. G. Corneil has been promoted to research associate in Humble Oil & Refining Co.'s Research and Development Division, Baytown, Texas. He conducts technical and economic studies for guiding the company's research work on petrochemicals. Also, he is responsible for making certain studies in the field of nuclear energy and determining Humble's long range interests in the nuclear energy field. Corneil holds a B.S. degree in chemical engineering from the University of Oklahoma.

Corneil

Theodore E. Casselman, Jr., assistant engineering manager in the Boston office of Stone & Webster Engineering Corp., has been named manager of the New York office. He joined Stone & Webster in 1940 after working on the engineering staffs of Worthington Corp. in Harrison, N. J., Jackson Engineering Corp., Tulsa, and American Locomotive Co., New York. Starting as a project engineer he has worked on the design of many chemical and petrochemical plants built by S&W. He was promoted to chief engineer, Chemical Division, in 1956, and was made assistant engineering manager in 1958. Casselman attended Stevens Institute of Technology and Massachusetts Institute of Technology where he obtained a degree in mechanical engineering. He is a member of ASME and the National Society of Professional Engineers.

Morgan J. Davis, president of Humble Oil & Refining Co., has been named probable president and director of the new Humble organization. Other officers who are probable incumbents are: **John W. Brice, William Naden** and **C. E. Reistle, Jr.,** executive vice presidents and directors, and **H. W. Ferguson, H. W. Haight** and **E. D. Reeves,** vice presidents and directors.

Naden and Reeves are presently president and executive vice president of Esso Standard Oil Co. Brice and Haight are presently president and chairman of the board of Carter Oil Co. Reistle and Ferguson are executive vice president and vice president of Humble.

It is expected that the new company's board will be considerably expanded as the needs of the new organization develop. Officers who are not directors

More clean water at a lower cost with...

S.P. KINNEY **AUTOMATIC SELF-CLEANING**

STRAINERS

... for efficient removal and disposal of suspended particles from raw or process water and other liquids

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- ✓ Over 8 billion gallons per day installed capacity
- ✓ Large variety of straining media

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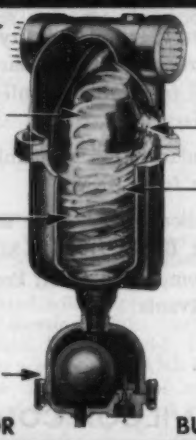
NEW T TYPE SEPARATOR
IMPROVED CYCLONE DESIGN
ASSURES MAXIMUM ENTRAINMENT SEPARATION


IN-LINE INSTALLATION
SCREWED OR FLANGED ENDS
LARGE, HI LEVEL OUTLET CHAMBER
HI SPEED ENTRY— MAX. CENTRIFUGAL ACTION
CLEAN DESIGN PRODUCES MIN. PRESSURE LOSS
ENTRAINMENT HUGS WALL FLOWS TO BOTTOM DRAIN
AVAILABLE IN SIZES TO 8" PRESSURES TO 1,000 P.S.I.
AUTOMATIC DRAINAGE WITH WRIGHT-AUSTIN FLOAT OR BUCKET TRAPS
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The Ridge Tool Company Elyria, Ohio, U.S.A.

THREADED PIPE... *It's Tight... It's Best... Costs Less!*

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A new name for carbon steel heat exchanger tubing

Dependability proved by five years' extensive field service. Sound—uniform—and priced for dollar-saving economy

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Now, B&W brings you a new concept in heat exchanger tubing—B&W LECTROSONIC. Produced under the most exacting quality control methods in the industry, LECTROSONIC tubing fits right, and rolls in easily because it's dimensionally accurate, and uniform.

Continuous ultrasonic inspection—plus destructive and hydrostatic testing, visual inspection, and magnetic particle inspection, are five ways used to check the weld of B&W LECTROSONIC Tubing for your assurance of dependability.

B&W LECTROSONIC Tubing was developed to meet the needs of the petrochemical industry for an electric resistance welded carbon steel tube that is easily workable, strong, and less costly than seamless tubing which it is designed to replace.

Produced in all standard sizes. Available now through distributors or direct from B&W.

Write for B&W Bulletin TB-431 for full information, or call your nearest B&W District Sales Office. The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pennsylvania.

B&W

THE BABCOCK & WILCOX COMPANY

TUBULAR PRODUCTS DIVISION

TA-9034-WP5

Seamless and welded tubular products, solid extrusions, seamless welding fittings and forged steel flanges—in carbon, alloy and stainless steels and special metals

Men . . .

have not yet been named and will be announced as they are selected.

The headquarters staff will be built slowly, and in the interim period directors will use the existing staff personnel of the various operating divisions as far as possible.

Augustus B. Small has been named a research associate by Esso Research and Engineering Co. He is a member of the firm's Chemicals Research Division where his activities are in the field of polymer research and development. With Esso Research 20 years, Small has spent 15 years at the affiliated Esso Research Laboratories, Baton Rouge, La., where he worked on projects associated with butyl rubber. He attended Mercer University and earned B.S. and M.S. degrees in organic chemistry.

S. R. Vandivort, an attorney at Shell Oil Co.'s head office, New York, has been named a general attorney. He will handle manufacturing, transportation and supplies, marketing, purchasing-stores and public relations legal matters. **R. M. Hart,** also an attorney at the head office, has been named a general attorney and will handle legal matters concerning finances, taxes, the secretary's office, personnel, and Shell Development Co.

John W. Russell has been promoted to assistant supervisor of the Process Engineering Department of the Ohio Oil Co.'s Robinson, Ill., refinery. He was formerly advanced process engineer. He went to work as a chemist at the refinery following his graduation in 1941 from Ohio State University with a degree in chemical engineering. A naval officer during World War II, Russell's wartime duties included testing and experimental work with petroleum fuels in marine engines.

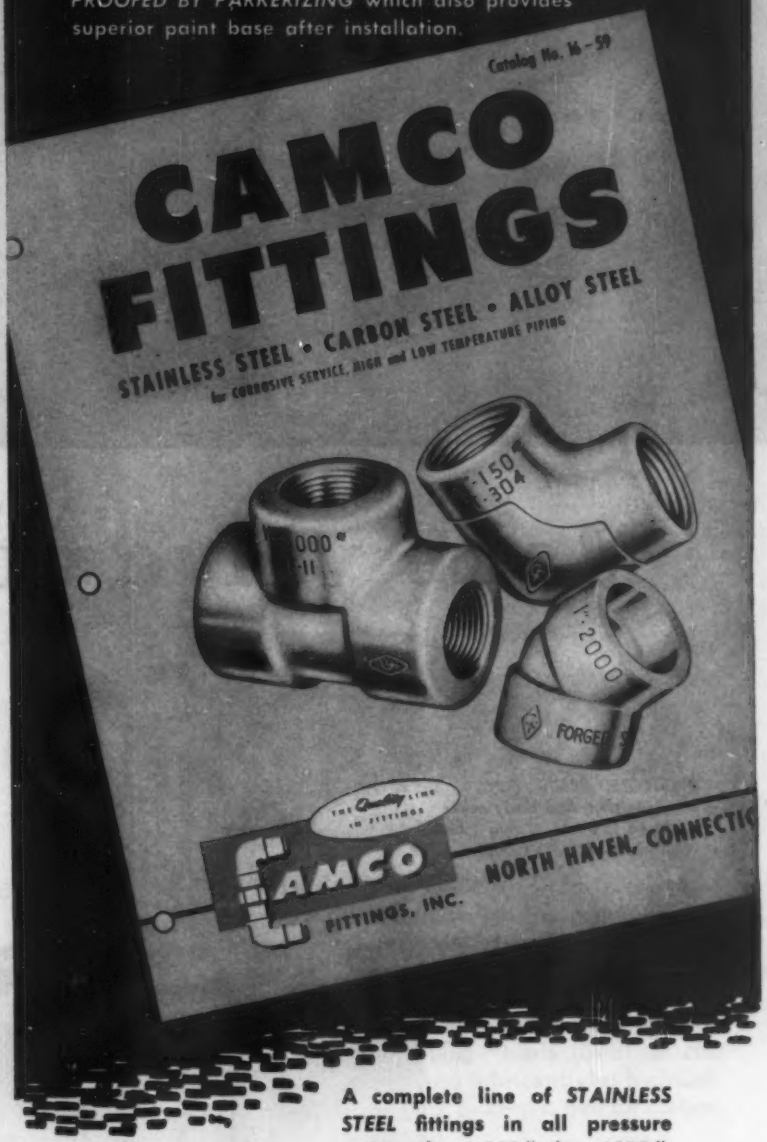
Graham B. Knight, a registered professional engineer in Texas, Massachusetts, and New York, has formed Advanced Technology Associates, a consulting engineering firm serve the chemical and allied industries. Previously with the process engineering firm of J. R. Minevitch and Associates, Inc., Knight has worked in process design, engineering and operation activities for E. B. Badger and Sons Co., Stone and Webster Engineering Corp., and Badger Manufacturing Co.

Dr. Bruce H. Sage, professor of chemical engineering at California Institute of Technology, has been named recipient of the 1959 William H. Walker Award of AIChE. The award will be presented during the annual meeting of the institute at San Francisco, December 6-9. It is given annually to a member of AIChE who is the author of co-author of an outstanding technical paper published by the Institute.

Dr. Sage has been on the research and teaching of Cal Tech since 1935. He was named professor of chemical engineering in 1944, and in 1945 became head of

now available . . .

FORGED STEEL screwed and socketweld pipe fittings (2000# thru 6000# rating) with all surfaces *RUST PROOFED BY PARKERIZING* which also provides superior paint base after installation.



A complete line of *STAINLESS STEEL* fittings in all pressure ratings from 150# thru 6000#.

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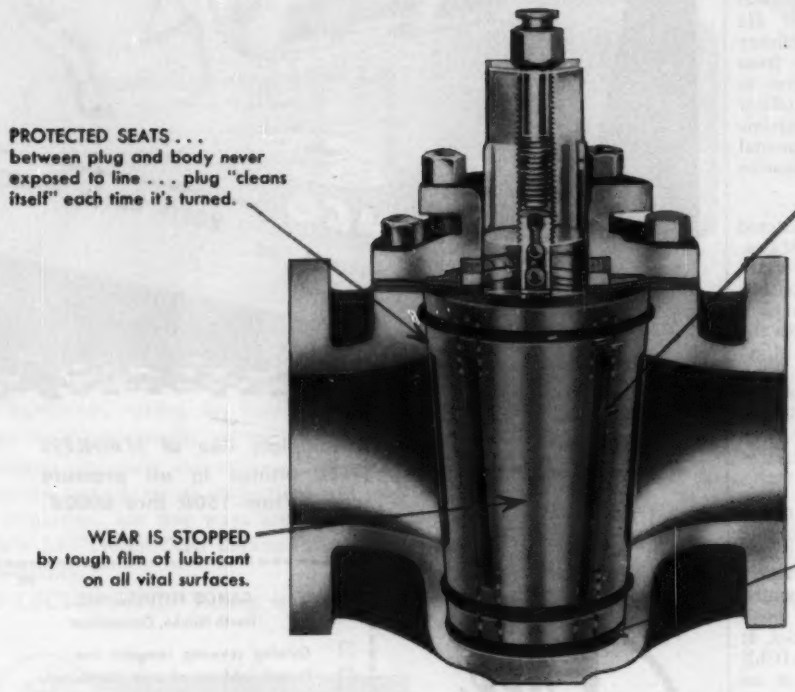
For more data on advertised products, use Readers' Service Cards, last page.

Make valve dollars go


PROTECTED SEATS . . . between plug and body never exposed to line . . . plug "cleans itself" each time it's turned.
LEAKPROOF operation assured by pressurized lubricant seals between plug and body.
WEAR IS STOPPED by tough film of lubricant on all vital surfaces.
CAN'T GALL because lubricant hydraulically "jacks" plug keeping it free for instant operation.

Lubrication makes the

farther with

LUBRICONOMY

"Lubriconomy" is a streamlined way of saying that valve lubrication *is* economy . . . it saves money by eliminating wear.

Lubrication in Rockwell-Nordstrom valves will make your valve dollars go farther because it eliminates the wear of metal-to-metal friction on *every* moving part. Comparing these valves to other types is simply comparing a lubricated to a non-lubricated mechanism . . . which would you expect to work better, longer and at lower cost?

But lubrication in Rockwell-Nordstrom valves does more than eliminate wear—it assures extraordinary leak-proof control and dependability. *Pressurized* lubricant in the exclusive Sealdport® system creates a powerful double seal against leakage. (Much like a puncture-proof tire, pressurized lubricant sealing "heals itself" if cut, scratched or worn). And lubricant also hydraulically cushions the plug to keep it free for *instant*, quarter-turn operation.

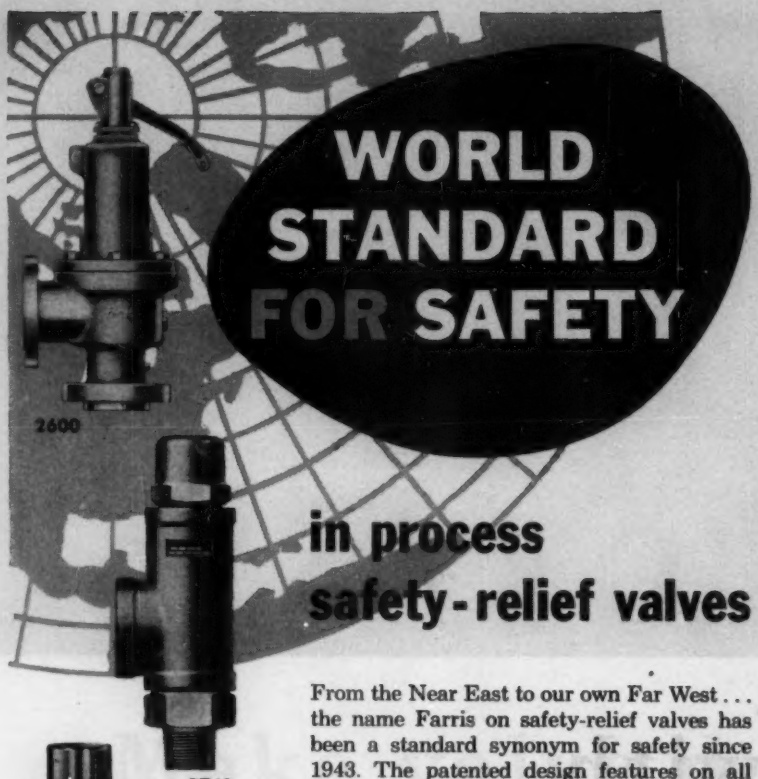
More than 6 *million* Rockwell-Nordstrom valves are saving money today on every imaginable type of service. Why don't you try just one where you've had valve problems? Write for details, or have a Rockwell field engineer visit you. Rockwell Manufacturing Company, Pittsburgh 8, Pa. Canadian Valve Licensee: Peacock Brothers Limited.

difference

ROCKWELL-Nordstrom VALVES

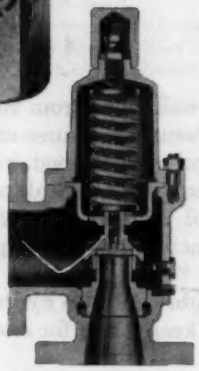
another fine product by

ROCKWELL



From the Near East to our own Far West . . . the name Farris on safety-relief valves has been a standard synonym for safety since 1943. The patented design features on all Farris full-nozzle valves combine to offer the ideal concept of a trouble-free, 100% safe safety-relief valve for every application.

2745


2950

SERIES 2600

The most popular top-guided, self-aligning, safety-relief valve for process piping service. Maximum pressure, 150 to 2500 psig. RF/RJ. Plain or Lever types. Standard or BalanSeal bellows construction.

SERIES 2740

A cast-steel relief valve of simplified design for use where extreme blow down accuracy is not essential, but where durability, compactness are. Pressures to 3500 psig at 450°F; 2000 psig at 800°F. Sizes ½" to 2".

SERIES 2745

An extremely rugged, compact, high pressure bar stock nozzle valve. Internal parts stainless steel. Adjustable blow down; flat seat; self-aligning stem and disc. Pressure to 10,000 psig. Sizes ½", ¾", 1".

SERIES 2950

A cast iron safety-relief valve including most of the exclusive Farris features found in the Series 2600. Max. pressure, 250 psig at 450°F, 400 psig at 150°F. Plain cap, open lever or packed lever types.

Complete information is provided in Catalog FE-11B, covering both selection and sizing of Farris process Safety-Relief Valves. Send for your copy today.

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Men . . .

the Explosive Department, Naval Ordnance Test Station, Inyokern, Calif. In 1949 he became associate director of engineering—then senior consultant of the Naval Test Station at Inyokern. He is co-author of some 200 scientific publications and five books on chemical engineering.

Lester R. Moore has been named secretary-treasurer of Esso Standard Oil Co. **Alan R. Martin, Jr.**, was named assistant secretary. Moore, Esso treasurer since 1946, succeeds **George M. Buckingham**, who transferred to Standard Oil Co. New Jersey. Moore has been in the Esso Treasurer's Department since he joined the company as a regular employe in 1928. Before he was elected treasurer three years ago, he had been an assistant division head in the department, and an assistant treasurer. He attended New York University and the University of Columbia Graduate School of Business.

Noyce Richey has been appointed associate professional chemist of Texas Butadiene & Chemical Corp. He graduated from Southwestern Louisiana Institute with a degree in chemistry. A member of ACS, ISA and ASTM, he was previously a section head in the Control Laboratory at Texas Butadiene, a job he had held since joining the company in June 1956. He was formerly with Cities Service Refining Corp.

Russell D. Karns has been named assistant treasurer of Pan American Petroleum Corp. He joined Pan American in 1934 and served in various capacities in the Accounting, Procedure and administrative departments until 1944, when he was named assistant to the president. Karns has been active in oil industry public relations activities for many years. He served two years as chairman of the

STATEMENT REQUIRED BY THE ACT OF AUGUST 24, 1912, AS AMENDED BY THE ACTS OF MARCH 3, 1933, AND JULY 2, 1946 (Title 39, United States Code, Section 233) SHOWING THE OWNERSHIP, MANAGEMENT, AND CIRCULATION OF PETROLEUM REFINER, published monthly at Houston, Texas, for October, 1959.

1. The names and addresses of the publisher, editor, managing editor, and business managers are: Publisher, Wm. G. Dudley, 4742 Banning, Houston, Texas; Editorial Director, Silas B. Ragsdale, 1636 North Blvd., Houston, Texas; Editor, George B. Gibbs, 9214 Timberside, Houston, Texas; Chrm. Editorial Committee, Dr. John J. McKetta, 4702 Fairview Drive, Austin, Texas; Managing Editor, Wallace Fitzgerald, 5433 Lymbar, Houston, Texas; Business Manager, Robert M. de Sombre, 4410 Ingersoll, Houston, Texas.

2. The owner is: The Gulf Publishing Company, Houston, Texas; June Wooden Bliss, Houston, Texas; June Wooden Dudley Bliss—Trustee, Houston, Texas; Mrs. Grace C. Carter, Dallas, Texas; Mrs. Margaret D. Cashman, Beaumont, Texas; Drum & Company, c/o Trust Department, Houston, Texas; P. Stinson Dudley, Abilene, Texas; Ray L. Dudley (Deceased), Houston, Texas; Wm. G. Dudley, Houston, Texas; Wm. V. Gross, Austin, Texas; Mrs. Carolyn Dodson Keeble, Abilene, Texas; Mrs. Anita S. Lane, Houston, Texas; Charles H. Lane, Houston, Texas; James William Nelson, Baytown, Texas; Tom W. Nelson, Houston, Texas; Mrs. Sallie Windham Ridley, Houston, Texas; Walter Gage Sterling—Trustee, Houston, Texas; O. R. Waller, Chicago, Illinois.

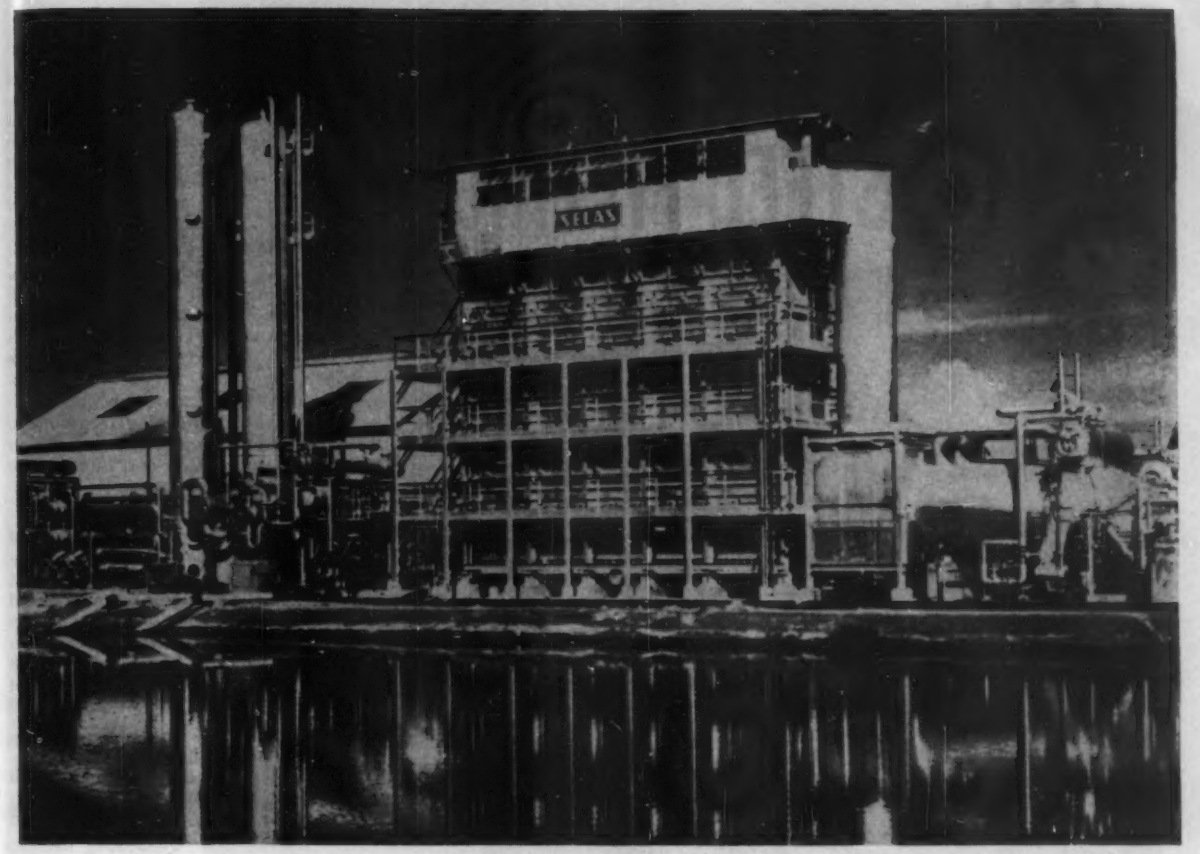
3. The known bondholders, mortgagees, and other security holders owning or holding 1 percent or more of total amount of bonds, mortgages, or other securities are: NONE.

4. Paragraphs 2 and 3 include, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting; also the statements in the two paragraphs show the affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner.

R. M. de SOMBRE
Business Manager

Sworn to and subscribed before me this 16th day of September, 1959.

P. J. AUCOIN
(Seal) Notary Public in and for Harris County, Texas.
(My commission expires June 1, 1961)



California Ammonia Co. is owned in partnership by Best Fertilizer Co., Lathrop, Calif., and a group of farmers. Using Calamco ammonia, Best produces ammonium sulfate and over 20 different grades of pelleted ammonium phosphates and dry mixes.

CALAMCO Relies on Selas Gradiation® Heating to Meet Varying Hydrogen Production Demands

This new Selas steam-methane reforming furnace — installed at California Ammonia Co.'s Lathrop, California, anhydrous ammonia plant—provides the necessary versatility to meet a wide variety of production demands.

Controlled heat, delivered to the vertical tubes by Duradiant® burners positioned in rows along the furnace walls, assures:

- Preciseness of heating . . complete combustion within Duradiant burner cup permits placing burners close to tubes . . achieving fast heat-up and instantaneous response to controller demand.
- Heat uniformity . . even-heat distribution along and around tubes increases tube life by eliminating hot spots, minimizing coke formation.
- Versatility . . Duradiant burners, readily adjustable to desired heat pattern (in either horizontal or vertical rows), provide CALAMCO with an extremely versatile heat processing tool.

For example, the ability to alter burner pattern, enables CALAMCO to produce hydrogen under any of the following conditions:

- Boost throughput to meet increased production demands, without changing conversion.
- Increase conversion without changing throughput . . resulting in higher product yield.
- Operate for maximum thermal efficiency, at design throughput and conversion.
- Operate at lower tube wall temperature, at design throughput and conversion.

May we arrange for a Selas field engineer to discuss your heat processing needs with you? For this service . . without cost or obligation to you . . or for a copy of Bulletin 710 "Gradiation Heating for Petroleum and Chemical Processing" and article reprint "Uniform Heat Raises Reformer Output," write to Mr. K. W. Fleischer, vice president, Fluid Processing Div., Selas Corporation of America, Dresher, Pa.

Gradiation and Duradiant are registered tradenames of Selas Corporation of America

SELAS CORPORATION OF AMERICA DRESHER, PENNSYLVANIA

Heat and Fluid Processing Engineers

DEVELOPMENT · DESIGN · CONSTRUCTION

For more data on advertised products, use Readers' Service Cards, last page.

Drop Forged from Solid Billets...

FORGED STEEL FITTINGS

Heat . . . pressure . . . turbulence . . . oxidation . . . vibration . . . reduction . . . shock. For critical installation problems like these, get maximum protection with W-S Carbon, Stainless and Alloy Steel Fittings.

- Drop forged to produce exceptionally high tensile and impact strength.
- Long accurate threads, in perfect alignment, for ease of installation.
- Heavy uniform fitting wall thickness—an important safety factor.
- Accurate machining to fit tight.

For your next order, call your nearby W-S Distributor. You'll find him ready with comprehensive stocks of the complete line of W-S high-quality fittings. *Forge & Fittings Division, H. K. Porter Company, Inc., Box 95, Roselle, New Jersey.*

FORGE AND PORTER FITTINGS DIVISION

H.K. PORTER COMPANY, INC.

PORTER SERVES INDUSTRY: with Rubber and Friction Products—THERMOID DIVISION; Electrical Equipment—DELTA-STAR ELECTRIC DIVISION, NATIONAL ELECTRIC DIVISION; Specialty Alloys—RIVERSIDE-ALLOY METAL DIVISION; Refractories—REFRACTORIES DIVISION; Electric Furnace Steel—CONNORS STEEL DIVISION, VULCAN-KIDD STEEL DIVISION; Fabricated Products—DISSTON DIVISION, FORGE AND FITTINGS DIVISION, LESCHEN WIRE ROPE DIVISION, MOULDINGS DIVISION, H. K. PORTER COMPANY de MEXICO, S. A.; and in Canada, Refractories, "Disston" Tools, "Federal" Wires and Cables, "Nepcoduct" Systems—H. K. PORTER COMPANY (CANADA) LTD.

Men . . .

Oil Activities Committee of the Tulsa Chamber of Comerce, and later was district chairman of the Kansas-Oklahoma District of the former Oil Information Committee, API. Most recently, he has been a member of the Advisory Committee on public relations of the Committee on Public Affairs, API.

George K. Spradling has been appointed supervisor of planning and scheduling in the Maintenance and Construction Department, Tidewater Oil Co.'s Avon, Calif., refinery. **Charles G. Moore** succeeds Spradling as engineering coordinator-planning, scheduling and estimating, in the Engineering Department. **Ernest F. Ehmke, Jr.,** has been selected as engineering coordinator-corrosion, in the Engineering Department.

L. S. Gibbs has been named head of Esso Standard Oil Co.'s Instrument Technical Service Division, Bayway, N. J., refinery. **E. J. Skivington** becomes head of the new Equipment Coordination Section, Maintenance Division, Bayway refinery's Mechanical Department. Both men have been with the company about 25 years.

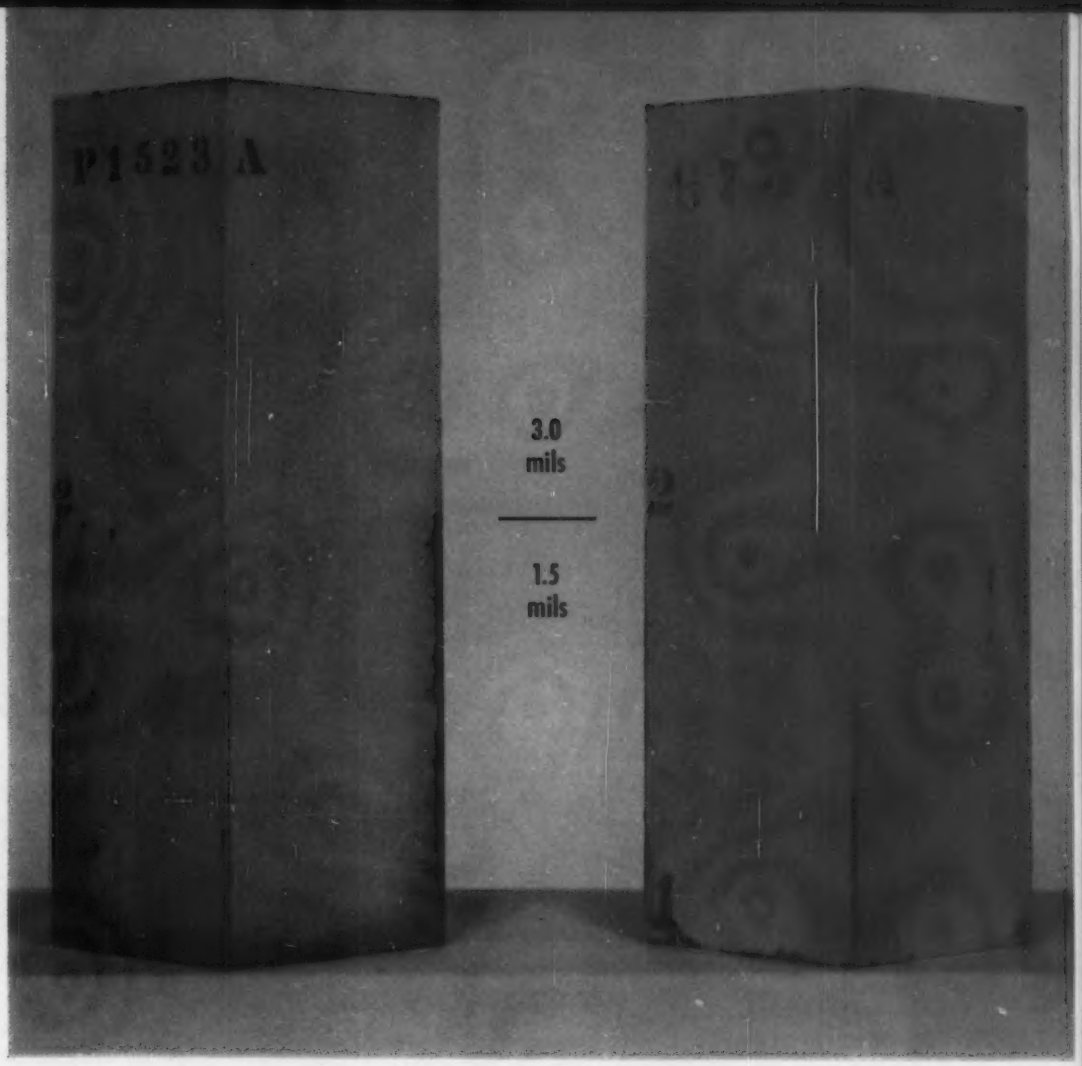
Ronald J. Dopp has been named controller of Clark Oil & Refining Co. With Clark since 1948, he will supervise accounting and tax activities. Dopp studied accounting at the University of Wisconsin and Marquette University, and worked with several large manufacturing firms before coming to Clark as office manager.

Dr. J. T. Richardson has been promoted to senior research physicist in Humble Oil & Refining Co.'s Research and Development Division, Baytown, Texas. He is engaged in the application of solid state physics in a fundamental catalyst research program. Dr. Richardson holds B.A. and Ph.D. degrees in physics from The Rice Institute.

J. Floyd Ladd has been elected treasurer of DX Sunray Oil Co. **Lewis Lacy** has been named secretary and **L. Millard Gelvin** assistant treasurer. Both hold similar posts with Sunray Mid-Continent Oil Co. Ladd has been with Sunray companies since 1929, Lacy joined Sunray Mid-Continent in 1955, and Gelvin joined the firm in April, 1959.

Dr. C. Vernon Foster has joined **Dr. H. C. Schutt,** consulting engineer, Boston. Dr. Foster has had experience as a group leader in Continental Oil Co.'s Research and Development Department, with Ethyl Corp. as process engineer and with C F Braun & Co in the Research Department.

F. William Schumacher, manager of Esso Standard Oil Co.'s Everett, Mass., refinery, has been named petroleum research coordinator at Esso headquarters,



Never before such durable protection, never before such lasting appearance in metal protective paints.

Proof anti-corrosion finish paints made with M50® pigment give unique freedom from bilging

Compare . . . for color . . . the gray alkyd finishes on the two exposure test angles shown above.

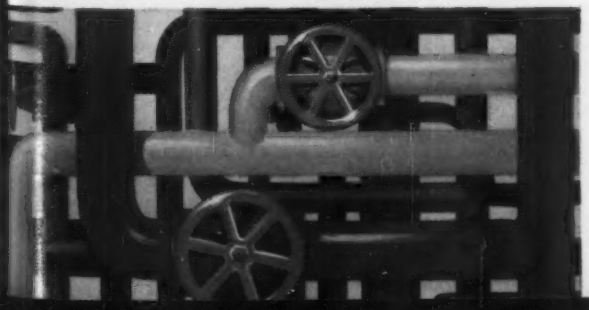
By all previous concepts for anti-corrosion paints, the one on the left should be the darker, should show some splotchiness . . . even though the paint on both angles came out of the same can. That's because the angle on the left was exposed (four years, 45°S) to the heavily sulfur-laden industrial atmosphere of Perth Amboy, N. J., while the angle on the right was exposed (four years, 45° S) only to the normal atmosphere found at National Lead's Sayville, L. I. Test Station.

As you can see, the color difference . . . bilging . . . that you might expect from SO_2-caused precipitation simply has not developed in this paint made with *M50* pigment.

Combined with its unique resistance to discoloration by the chemicals found in industrial atmospheres, fused M50 basic lead silico chromate pigment demonstrates exceptional rust inhibitive action.

Now, with *M50* pigment, your regular paint suppliers can provide standard or heavy-coat anti-corrosion primers, intermediates and finishes with superior rust inhibition, superior weather resistance, and excellent tintability. Paints that are more durable and don't bilge. The *M50* pigment is suitable for use with a wide variety of vehicles.

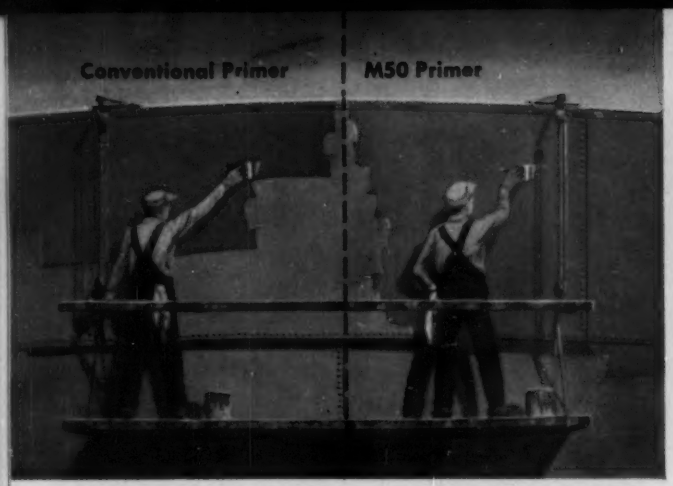
Color code paints look better longer, are more protective, too, with M50 pigment.



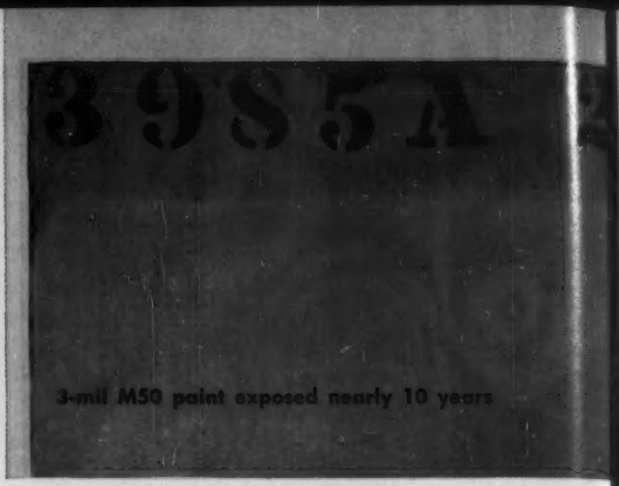
See, on the next page, more details . . . and how you can get these new, much more durable anti-corrosion paints.

M50 pigment is a product of National Lead Company

General Offices: 111 Broadway, New York 6, N. Y.



Weight for weight, anti-corrosion paints made with high-bulking M50 pigment cover 40% to 60% more steel.



Mil for mil, M50 paint films show better rust-inhibitive performance, lengthen the painting cycle interval.

Here's evidence M50 pigment paints reduce anti-corrosion maintenance painting costs two ways

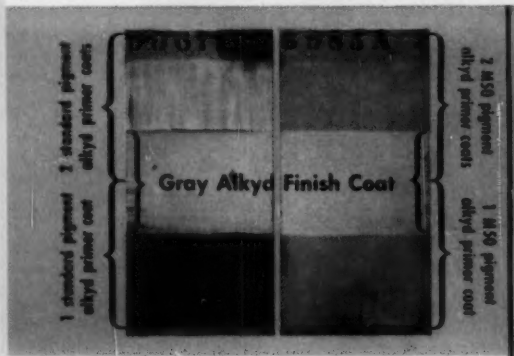
On the preceding page you have seen evidence that *M50* pigment paints are unique among anti-corrosion paints for anti-bilging properties. Exposure tests at National Lead's Sayville, L. I. Test Station have demonstrated these metal-protective paints are also unique for their anti-corrosion action, their weather-resistance, their color stability and many other performance characteristics.

Above you see evidence that *M50* pigment paints are equally unique in their ability to provide anti-corrosion maintenance painting economy. The illustration at left gives you a visual comparison between the coverage of a conventional anti-corrosion primer and an equal weight of an *M50* counterpart of this same primer (Fed. Spec. TT-P-86a, Type I). Clearly a given weight of *M50* pigment paint goes further.

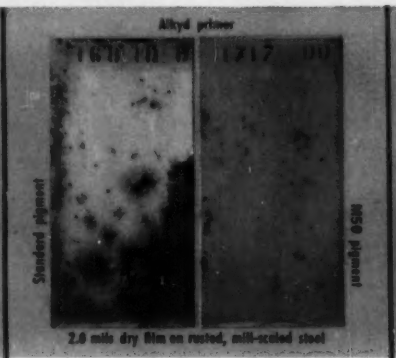
The picture at the right shows the condition of a 3-mil *M50* pigment *primer* exposed nearly 10 years *without a finish coat.* You can see that even in this severe test . . . an unprotected primer . . . anti-corrosion action is still being obtained. The repainting surface is still in good shape. Weather has not adversely affected protection. Imagine how many years of service you can anticipate from anti-corrosion *M50* finish coats applied over anti-corrosion *M50* primers in the normal or heavy coat systems!

Based on cost per sq ft per year, M50 pigment paints can greatly reduce the cost of your anti-corrosion maintenance painting.

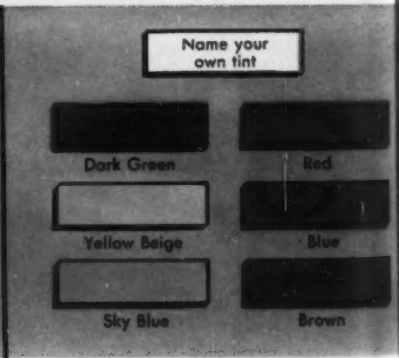
Why M50 Defense in Depth paints give anti-corrosion beyond all former concepts


1 standard pigment alkyd primer coat
2 standard pigment alkyd primer coats
Gray Alkyd Finish Coat
1 M50 pigment alkyd primer coat
2 M50 pigment alkyd primer coats

Exposed 9 years, 45°S. Each coat 1.5 mils
Proved corrosion and weather resistance



Exposed 45°S; 1 yr ind. atmos, 1 yr normal atmos.
Proved outstanding for film strength, durability



Colors above available in conventional and heavy-coat paints
A wide range of stable colors can be produced

Are you concerned with tank or structure maintenance painting in your firm? If so, you are invited: (1) to visit National Lead's Sayville, L.I. test station, where you will see the results of the 20 years research that lies behind the *M50* pigment particle and the more than 10 years of exposure testing that lies behind *M50* pigment Defense in Depth paints; (2) to send coupon below for National Lead booklet, "Defense in Depth" and typical *M50* tank paint specifications.

Next time you purchase, specify *M50* pigment paints. Any paint manufacturer can supply you.

M50 Defense in Depth

National Lead Company,
111 Broadway, New York 6, N. Y.

Gentlemen: Please send me the "Defense in Depth" booklet together with typical tank paint formulas and color chips that I can use in specifying M50-type tank paints.

Name_____ Title_____

Firm or Dept._____

Address_____

City_____ State_____

Men . . .

New York. **William J. Sheridan,** operations superintendent at the company's Bayway refinery, Linden, N. J., succeeds Schumacher as Everett refinery manager.

Schumacher joined Esso in 1930, following graduation from Cornell University. In 1935 he transferred to Esso Research and Engineering Co. He returned to Esso Standard early in 1954 as manager of the company's Technical Service Division, where he had begun his company career as a student engineer. In December, 1954, he moved to the Everett refinery as manager. His last post with Esso Research was as associate director, Process Division.

Sheridan was previously head of the Technical Department, process superintendent and assistant general superintendent at Esso's Baltimore refinery before transferring to the Bayway refinery in March, 1955. He served as employe relations manager and as administrative superintendent at Bayway for more than three years and was named operations superintendent of the refinery last November.

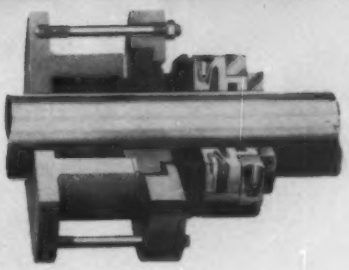
Dr. Elton Soltes, manager of Delhi-Taylor Oil Co.'s special projects, has been named to head the Special Projects and Planning Division, succeeding retiring vice president **J. W. Bartlett.** Soltes joined Delhi in 1950 as a chemical engineer and became manager of special projects in December, 1958. He holds a Ph.D. degree in chemical engineering from The University of Texas.

G. R. Gamble, formerly supervisor of the treasurer's staff, has been transferred to the division as director of the new Planning Department, which will accumulate and analyze data to aid management in long-range planning. Gamble joined Delhi in 1953 and held several positions in the Accounting Department before becoming supervisor of the treasurer's staff. He has a B.S. degree in electrical engineering and a M.B.A. degree in accounting from Texas Technological College.

Frank M. Coker has been named engineering adviser for the Special Projects and Planning Division. Vice president of Delhi Pipeline Corp., he holds a civil engineering degree from Texas Technological College, and joined the company as an engineer in 1950.

Dr. Melvin DeGroote, vice president for research, development and patents of Tretolite Co. Division of Petrolite Corp., St. Louis, and holder of 909 patents, has been selected to receive the 1959 Midwest Award of the ACS, St. Louis Section. The award is given annually to a Midwestern scientist in recognition of "meritorious contributions to the advancement of pure or applied chemistry or chemical education." The 1959 award will be presented to Dr. DeGroote at a section dinner November 7. The award ceremonies will be preceded by an all-day technical symposium. Dr. DeGroote was chosen for this honor in recognition of the role he

LAST LONGER IN CORROSIVE CHEMICALS



Garlock Chemiseal® Mechanical Seals possess greater immunity to corrosion and are more economical than any other design offered. This reputation is based on fact—customers report unsurpassed performance on applications like these:

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- **Pumping CONCENTRATED SULFURIC ACID** 1750 rpm. 1⅛" shaft. 2 lbs. suction. 45 lbs. discharge. Temperature of medium 65° C. RESULT: Chemiseal gave longer life.
- **Pumping ADIPIC ACID AND HYDROCARBON SLURRY** 1750 rpm. 1⅛" shaft. 35 lbs. suction, 75 lbs. discharge. Temperature of medium 70° C. RESULT: Chemiseal lasted longer, cut downtime.

Join the list of satisfied users. You can apply standard Garlock Chemiseal Mechanical Seals to all pump shafts from ⅜" to 2⅛". Special sizes also available. They seal against all mediums—including solids in suspension—in pressures to 100 psi at 75° C, or 75 psi at 100° C. Chemiseal Mechanical Seals are another of the Garlock 2,000 . . . two thousand different types of gaskets, packings, and seals for every need. Find out complete details by contacting your local Garlock representative, or write for Catalog AD-164.

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Canadian Div.—The Garlock Packing Co. of Canada Ltd. • Plastics Div.—United States Gasket Co.

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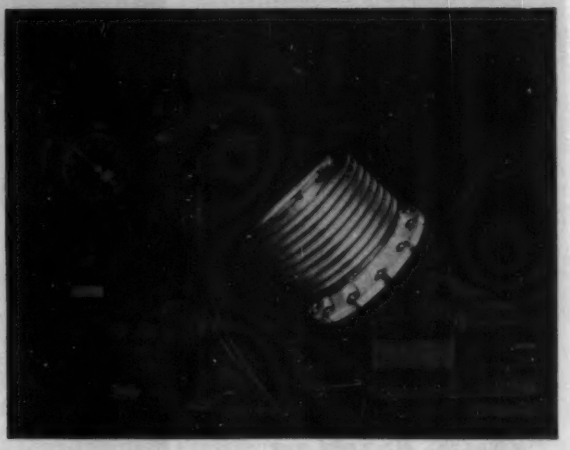
4 WAYS to get maximum reliability in expansion joints

1 Insist that the corrugated bellows be hydraulically formed. The reason is simple. Whenever bellows are formed by circumferential welding . . . whether by edge, seam or fillet welding . . . they will always be subject to premature failure because of stress concentrations at the welds.



2 Be sure the manufacturer maintains a continuous and comprehensive program of endurance testing. This is basic, because of the many variables that affect expansion joint life. Accurate determination of expansion joint life expectancy can only be determined by cycling to destruction.

3 Demand proof that the manufacturer can produce longitudinal welds in the corrugated bellows having the same strength, physical properties and thickness as the parent metal . . . without grinding. A weld that is hard to find is a ground weld. Variations in weld thickness set up points of stress concentration . . . opening the way for premature failure.

4 Check the ability of the manufacturer to supply a team of *competent* design and application specialists to work with your engineers. Check their specific experience in handling critical, complex applications in your field . . . complete to the record of successes or failures behind them, and details of how this experience will be brought to bear on your problem.

At Zallea, none of the many factors affecting expansion joint reliability are left to guesswork . . . including the four vital ones above.

This is reflected in these facts. Zallea material specifications are the most exacting in the industry. Zallea expansion joints are hydraulically formed. Zallea advanced welding techniques insure welds having the same thickness, strength and physical properties as the parent metal. Zallea has done more cyclic testing to destruction than all government agencies and industrial firms combined. Zallea has produced more expansion joints than any other manufacturer . . . offers more application engineering experience.

For all the facts, write for Catalog 56. Zallea Brothers, Taylor and Locust Streets, Wilmington 99, Delaware.

Zallea for maximum reliability

ZALLEA BROTHERS, Wilmington 99, Delaware • World's largest manufacturer of expansion joints

Men . . .

played in the development of crude oil demulsification and for his skill in the art of patent coverage.

A. J. Weith has been appointed director of petrochemicals and mining chemicals research for the Organic Chemicals Division, American Cyanamid Co. Dr. Weith, a graduate of Duke University, has been with Cyanamid since 1947, when he joined the company as a research chemist at the Stamford, Conn., Laboratories. For more than five years he served Cyanamid's Industrial Chemicals Division in numerous technical capacities. In 1952 he joined the Petrochemicals Department, Organic Chemicals Division, becoming departmental sales manager in 1956.

Dr. Weith served last year as industry advisor to the Chemical and Rubber Division, Business and Defense Services Administration, U.S. Department of Commerce. He is a member of the Commercial Chemical Development Association, and ACS.

Paul F. Schmidt has been named chief process engineer to the chief technical supervisor in El Paso Natural Gas Products Co.'s Engineering Department. He will be responsible for all technical activities of the company, including process engineering, technical service, and instrument and utilities engineering.

Formerly chief electrical engineer for the company, **James C. Arnold,** has been named chief general engineering supervisor. Arnold will be responsible for civil, electrical, mechanical, and project engineering activities.

Keith Claiborne replaces Schmidt as chief process engineer, and **J. H. Riddle** becomes chief, technical services. Riddle was formerly assistant to the superintendent of refineries.

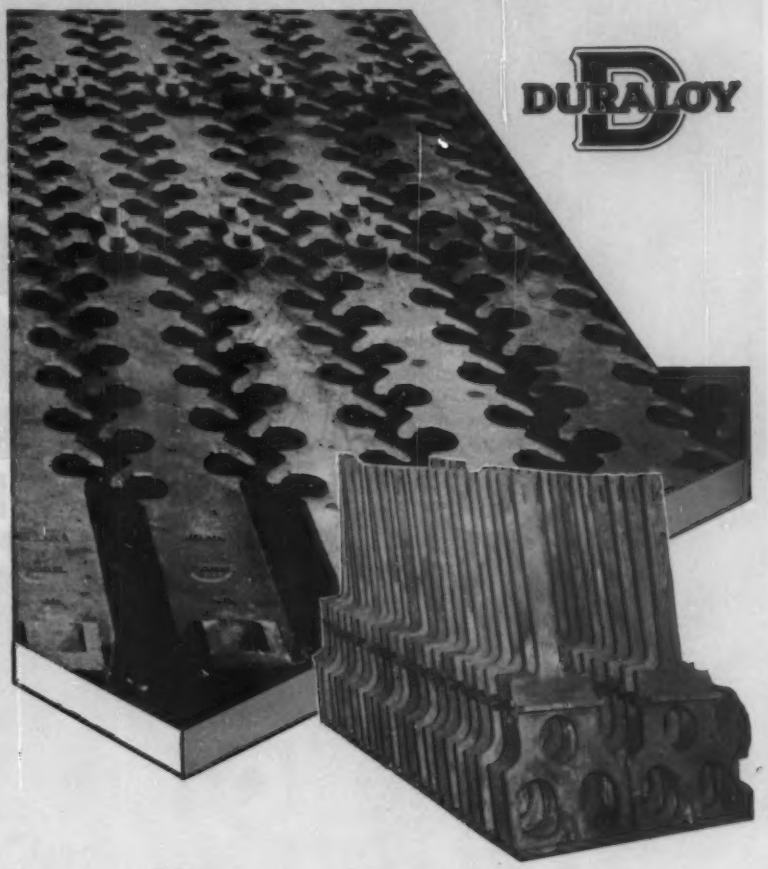
B. C. Shaul and C. L. Persyn have been appointed general superintendent and operating superintendent, respectively, of Tidewater Oil Co.'s West Coast refinery. Both positions are new. Shaul will coordinate and direct the refinery's engineering, maintenance and construction, employe relations, accounting and technology and control laboratories. He will be in charge of the plant in the absence of the Western Division's manufacturing manager, **Oscar Larson,** who will divide his time between the Avon refinery and the company's Western Division headquarters in Los Angeles. Persyn will coordinate and direct activities of all process facilities as well as shipping and utilities at the Avon refinery.

E. F. Courtney has been appointed to the new post of superintendent, petrochemicals.

H. L. Benson succeeds Shaul as superintendent, engineering, maintenance and construction, and **S. A. Bordi** becomes superintendent, distillation, reforming and treating, the post formerly held by Benson.

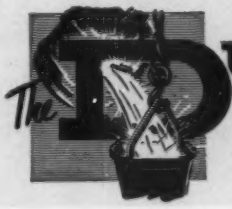
C. C. Carmine has been appointed

CORROSION RESISTANT
HEAT RESISTANT
Tube Supports



You can't buy Better Tube Supports . . . DURALOY Tube Supports are alloyed to meet individual corrosion and heat requirements. They are alloyed by experienced metallurgists and melted and cast by experienced high-alloy foundrymen, both groups with experience going back some thirty years. Castings are carefully tested in our own laboratories which are completely equipped for metallurgical, chemical and physical testing.

Many refineries have been DURALOY customers for years. Many refineries insist upon DURALOY castings. Whether it's straight production or engineering plus production, we are equipped to do the job. For more information, send for Bulletin No. 3150-G.



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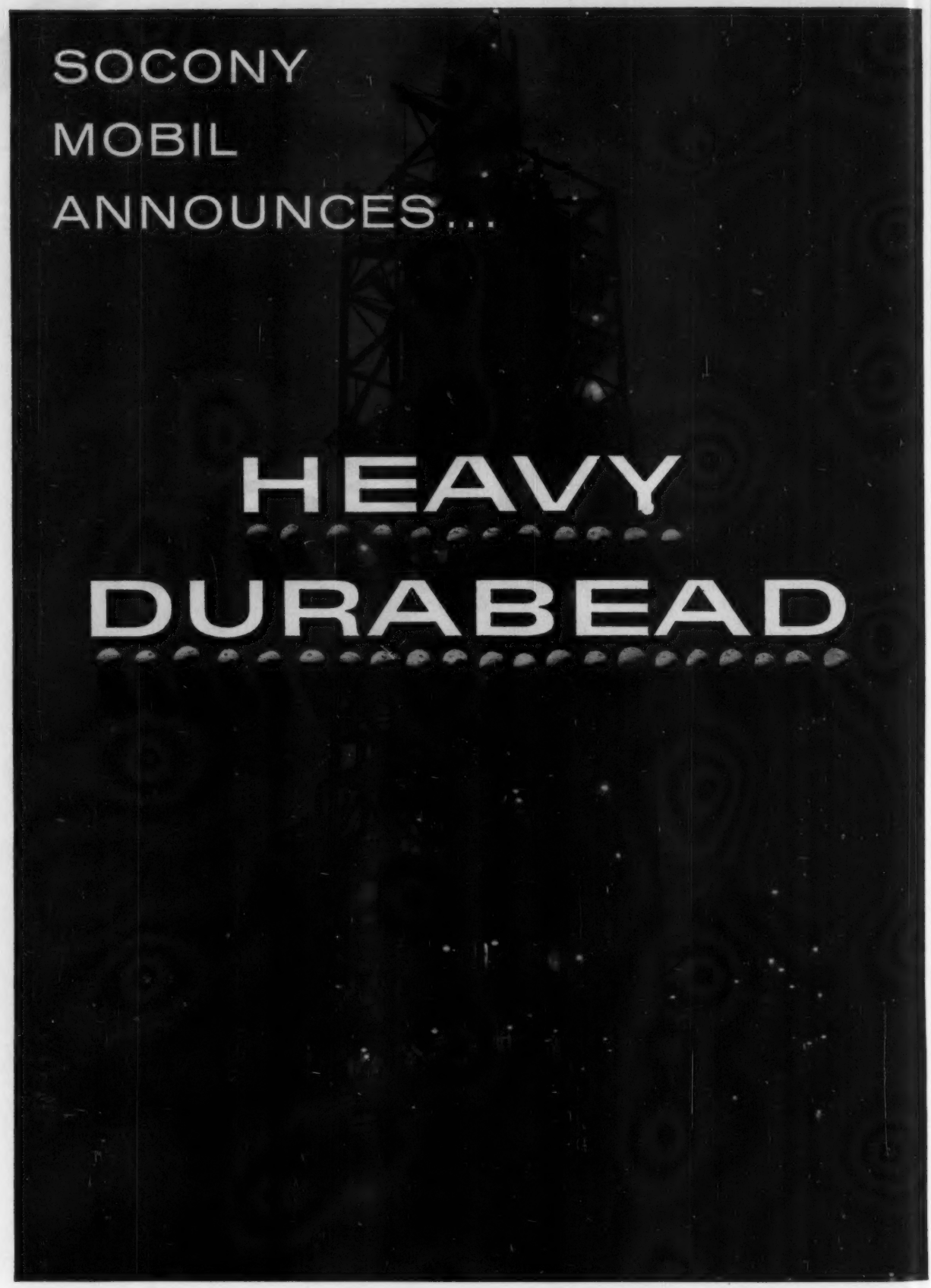
CHICAGO OFFICE: 332 South Michigan Avenue
DETROIT OFFICE: 23906 Woodward Avenue, Pleasant Ridge, Mich.

For more data on advertised products, use Readers' Service Cards, last page.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NOW SOCONY MOBIL'S CATALYST RESEARCH BRINGS YOU:

Lower operating costs
Greater cracking capacity
Reduced construction costs

For years Socony Mobil's scientists have been leaders in catalyst research and engineering. In 1943 they put the first Thermofor Catalytic Cracker on stream. Under wartime pressure they originated and perfected for commercial use the first bead catalyst. With the war over, Socony Mobil researchers continued to improve catalytic refining. By 1950, the Airlift TCC was an accomplished fact. Then in 1957 came Durabead, a bead catalyst that reduced cracking costs, increased refinery efficiency.

Now Socony Mobil catalyst research brings the petroleum industry another important advance—Heavy Durabead!

This new bead catalyst offers all of the advantages of Durabead—plus important new ones. It makes possible construction of TCC units at a 20% reduction in cost. Used in present TCC units, it increases reactor and regenerator capacities as much as 50% compared to chrome bead catalyst.

Once again Socony Mobil leads the way in producing a higher yield of salable products from a barrel of oil—making possible more profit for TCC licensees and operators of other moving bed cat crackers.

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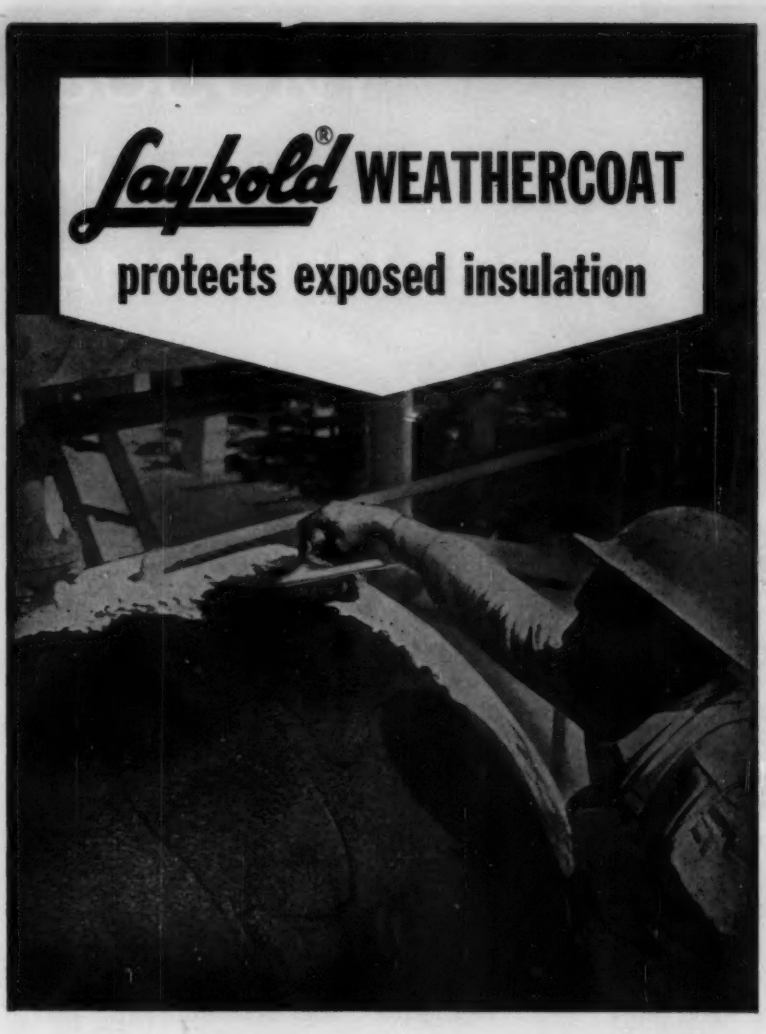

INSULATION on towers, tanks and exchangers must be kept DRY. If moisture gets through, the efficiency drops.

Modern refinery and plant design places many major insulated vessels "in the open." You can maintain the efficiency of your insulation with easy-to-apply Laykold Weathercoat.

Weathercoat is a fibrated asphalt-base material of easy troweling consistency that dries to a black, remarkably tough and tenacious coating. A majority of the leading refineries are regular users of Weathercoat.

A new product: Mastic Weathercoat, a bodied material, for use wherever economy demands the application of a *single,* thick layer.

Write today for free illustrated brochure, entitled "Laykold Weathercoat for Insulation Protection."

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Men . . .

superintendent, shipping and utilities, succeeding Courtney, while **P. B. Williamson** takes the position of superintendent, cracking, previously held by Persyn.

R. N. Johnson, chief technologist, assumes the newly designated post of staff assistant to the division manufacturing manager.

J. A. Mawhinney, Jr., manager of the Training Division in Shell Oil Co.'s head office Employe Communications Department, will become manager of the Wage and Salary Division of the head office organization and Salary Department. He succeeds **R. M. Lee,** who will become staff manager in the new Administrative Services Department in the head office exploration and production organization. **R. W. Hester,** assistant manager of the Policy and Benefits Division in the head office Personnel Department, will succeed Mawhinney as manager of the Training Division.

Mawhinney holds a B.A. degree in psychology and business from Davidson College and a M.A. degree in business from Columbia University. He joined Shell in 1940 as a clerk. Lee received his B.A. degree in political science from Pomona College before joining Shell in 1938 at Long Beach, Calif. He was named to his present position in 1956. Hester began his career with Shell in 1940 in the Marketing Department in Southern California. After service on the West Coast, and in Tulsa, Calgary, Denver and Midland, he moved to the head office in January, 1957, and was named assistant division manager in policy and benefits later that year.

R. A. Feagan, Jr., has been named North Texas-New Mexico Division gas superintendent by Pan American Petroleum Corp. He replaces **J. C. Conner,** who recently moved to Chicago on special assignment with Standard Oil Co. (Indiana). Feagan attended Columbia high school and the University of South Carolina, where he earned a B.S. degree in chemical engineering in 1939. He joined Pan American in 1946 as process engineering supervisor. Since 1951 he has held the title of plant engineering supervisor. In his new assignment, Feagan will be responsible for coordinating gas purchase and sale activities in North and West Texas, Eastern New Mexico and the Four Corners region. He is a member of ACS.

Frederick S. Mallette, 53, executive secretary of the Air Pollution Controls Committee, ASME, died September 10, at his home in Riverside, Conn. Internationally known for his work on air pollution problems, Mallette also served as editor of *Smog News,* ASME information bulletin. He had been with the Society since 1952. He had also arranged the First International Congress on Air Pollution, held in New York in 1955, and had been working on details of a second such conference.

THIS CHIKSAN MARINE LOADING SYSTEM INCREASES FLOW CAPACITY, REDUCES OPERATING COSTS FOR UNION OIL

What you see in the photo above is a Chiksan Marine Loading System on a new multi-million dollar supertanker terminal at Los Angeles operated by Union Oil Company of California. Designed to speed unloading operations, this Chiksan System has five 12 inch by 52 foot arms, three normally in crude oil and two in bunker oil service.

Each arm is capable of handling 15,000 B/H of refined product and up two 11,000 B/H of crude; a greater capacity than any method previously used by Union Oil.

Translated into faster turn around time, this increased flow capacity coupled with other savings through such factors as improved safety conditions results in significantly lower operating costs for Union Oil.

Plan now to install the Chiksan Marine Loading System at your terminal. For full information and recommendations, contact Chiksan.

100-105 PSI ACROSS THE RAIL is safely handled by the Chiksan all metal arm. In addition, smooth interior diameter reduces turbulence permitting more efficient pumping flow.

CLEAN, COMPACT DESIGN has permitted substantial construction savings in some cases through use of smaller docks to house equipment, and outboard dolphins to handle mooring lines.

#59-47

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CHIKSAN COMPANY—Brea, California • Chicago 5, Ill. • Newark 2, N. J. • Weco (Division), Houston 24, Texas • Subsidiaries: Chiksan Export Co. • Chiksan of Canada Ltd.

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Suppliers Notes...

George Koch has been named director of commercial development for Nuodex Products Co., a division of Heyden Newport Chemical Corp. He has engaged in research, technical service and commercial development activities for the past ten years. Koch was previously with Chas. Pfizer and Co., Inc., in research and development activities for industrial chemicals as well as agricultural and biochemical investigations.

Koch

C. W. Powell has been appointed manager, Southern District, for the Metallurgical Products Department, General Electric Co., Atlanta. With G-E for 23 years, he is a former manager of the Pittsburgh District office, and has been a salesman in St. Louis, Cleveland and Chicago. Most recently he was with the Chicago office as a sales specialist. Powell is a graduate of DePauw University where he majored in physics.

Powell

Thomas W. Wright has been named assistant manager, New York District sales office, The Babcock & Wilcox Co's. Tubular Products Division. Formerly a sales representative in the New York District, he began with B & W in 1946 and worked as a contact metallurgist at the Tubular Products Division's Beaver Falls plant. Wright is a graduate of Yale Engineering School, where he received a degree in Metallurgy.

Wright

Carra L. Lane has been appointed manager of plant operations for Chicago Pneumatic Tool Co., New York. All manufacturing and engineering operations in the Company's domestic plants, will be under his jurisdiction. He will also coordinate operations at the company's wholly-owned subsidiaries: The Jacobs Manufacturing Co., West Hartford, Conn.; The Allen Manufacturing Co., Bloomfield, Conn.; and REICHdrill.

Lane

Anthony M. Johnson has been named assistant marketing manager for the Systems Division, Beckman Instruments, Inc., Anaheim, Calif. He had been manager of systems applications engineering. With Beckman since 1953, he formerly was a regional manager for the company's Scientific and Process Instruments Division. Earlier he was technical services manager for Mineral Pigments Corp., Muirkirk, Md.

Johnson

Charles H. Dresser, vice president of industrial sales for Anderson-Prichard Oil Corp., has retired. With Anderson- Pichard for 39 years, he has been vice president of industrial sales since 1946. Before that, he was director of industrial sales. Dresser's initiation into the oil industry was with Marland Oil Co. His first job with them in 1919 was bucking tongs on a pipeline gang.

Dresser

Hector P. Broncher has been named vice president, marketing, Dresser Industries, Inc., Dallas. He had previously been an operating vice president of Dresser. Before that, he was general manager of Dresser Manufacturing Division, Bradford, Penn. Broncher joined the Manufacturing Division in 1929, and was appointed general manager of the company in 1941. He is a graduate of the University of Cincinnati.

Broncher

Bobby G. Stoops, assistant chief engineer at Rockwell Manufacturing Company's Instrument Division, Tulsa, has been promoted to chief products engineer. He joined Rockwell in 1955 as a design and development engineer and attained his most recent position in 1957. Before joining Rockwell he was with National Supply Co., and T. D. Williamson, Inc. Stoops is a mechanical engineering graduate.

Stoops

Dr. Clifford E. Berry, formerly assistant director of research, Consolidated Electrodynamics Corp., has been appointed director of engineering, Analytical & Control Instrument Division. He joined CEC as a staff physicist in 1942, became chief physicist in 1950, and assistant director of research in 1952. Dr. Berry was chairman of the 1959 Gordon Research Conference on Instrumentation.

Berry

William C. Walters has been named a liaison engineer and production coordinator, Pacific Pumps, Inc. He attended Compton Junior College and U.C.L.A., served in the Air Force from 1943-45 and for five years thereafter was with Emsco Derrick & Equipment Co. as a designer and engineer. In 1950, he joined Axelson Manufacturing Co., where he held several engineering and sales executive positions.

Walters

Earl B. Cutter, Jr., has been named Southern District manager of American Meter Co.'s Southwest Division, Dallas. He had been assistant to the vice president, sales. Cutter is a graduate of Iowa State College in mechanical engineering and joined American Meter in 1939 as a sales engineer. From 1955-57, he was chairman of the Meter and Regulator Division, Gas Appliance Manufacturers Association.

Cutter

Dr. Charles F. Robinson has been named an associate director of research, Consolidated Electrodynamics Corp. He joined CEC in 1947 as a staff physicist, became senior physicist in 1952 and chief research physicist in 1958. Previously, he was a National Research Council Predoctoral Fellow at California Institute of Technology; resident supervisor, Goldstone Lake Rocket Weapon Test Center; and staff

Robinson

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THERMOCOUPLE WELLS

Here's valuable help in the often-perplexing job of picking the right thermocouple wells and assemblies for particular applications.

This new Honeywell catalog brings you a wealth of useful data . . . provides all the information you need to make the right selection every time. Included in the catalog are:

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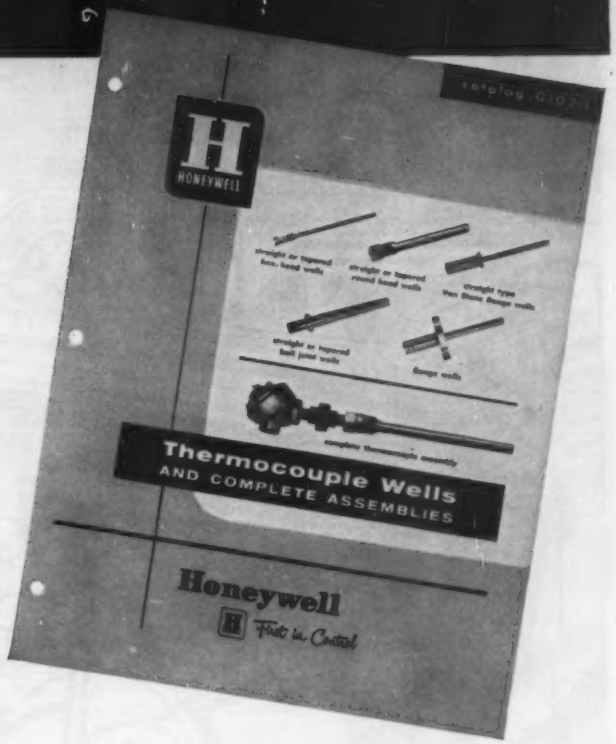

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now . . . longer life, improved performance for pipelines, crude units . . . with Unicor

Are you aware of the tremendous difference a small amount of Unicor can make in pipelines and crude units?

This film-forming, oil-soluble inhibitor prevents all kinds of corrosion. Wherever Unicor has plated out on a surface, it gives protection to tanks, vessels and pipelines whether full, part-full or empty.

By adding a small amount of Unicor to your product—10-20 parts to a million—you prevent product contamination, profit-robbing corrosion; assure maintenance of full-flow capacity and output.

Furthermore, use of Unicor substantially reduces filter cleaning and replacements, scraping operations, power costs and expensive downtime.

What Unicor does for tanks and pipelines it also accomplishes in crude units and other refinery equipment. For detailed information, write to our Products Department.

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Suppliers . . .

physicist, Cedars of Lebanon Hospital and Clyde K. Emery Medical Group. Dr. Robinson has a A.B. degree in science and mathematics from Southwest Missouri State College, a B.S. degree in mathematics and physics from Drury College, and M.S. and Ph.D. degrees in physics and mathematics from Cal Tech.

O'Brien

Rankin

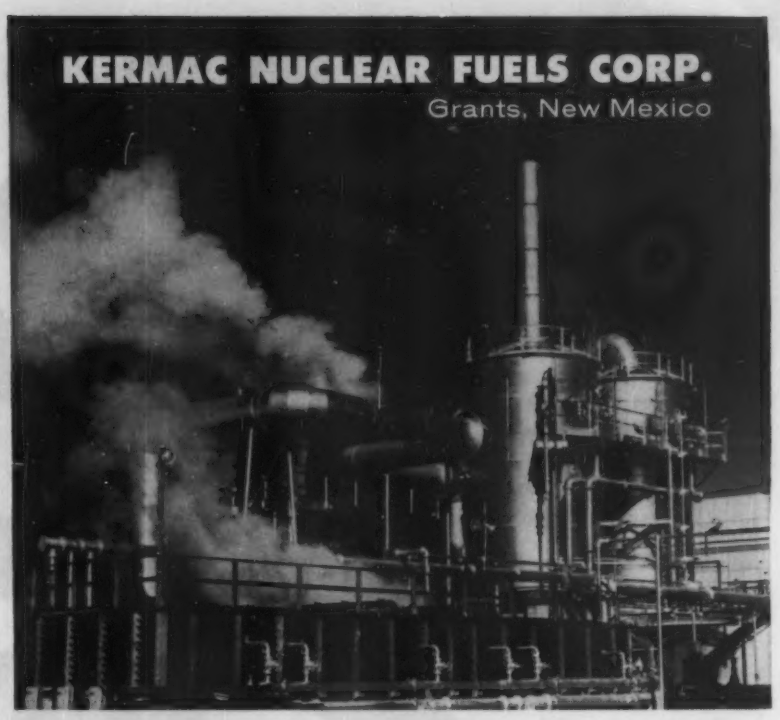
JONES & LAUGHLIN SUPPLY DIVISION has assigned **B. G. O'Brien,** salesman at Salem, Ill., to Greensburg, Ky. **J. H. Rankin,** salesman at Kermit, Texas, is assigned to Hobbs, N. M. O'Brien joined J&L as a storeman at Perry, Okla., in 1943, and Rankin has been with the company since 1957.

BECKMAN INSTRUMENTS, INC., has named **Michael York** corporate manager of advertising, Fullerton, Calif. He formerly was advertising and sales promotion manager for Beckman's Helipot Division. With the company since 1953, York will be responsible for the coordination of advertising programs maintained by the company's divisions, and creation and execution of corporate advertising and promotion programs.

BENDIX COMPUTER DIVISION has named **Ronald Compton** senior engineer for computer design at the main plant, Los Angeles. He has been an associate engineer at the division and previously was with Librascope, Inc. He is a graduate of the University of California and a member of the IRE.

LEEDS & NORTHRUP CO. has named **C. Reed Cary,** former senior vice president, chairman of the board. **Daniel H. Schultz** has assumed Cary's post as senior vice president. Former assistant to the president, **George E. Beggs, Jr.,** has been elected executive vice president and a director.

CONSOLIDATED ELECTRODYNAMICS CORP. has appointed **J. F. Bartholomew** district sales manager, New York. **Robert R. Donaldson** will be district sales manager, Boston. Bartholomew had been a field engineer in the New York district office, Hasbrouck Heights, N. J., since he joined the company in 1957. He is a graduate of Pratt Institute with a B.S. degree in electrical engineering and is a member of AIEE and ISA. Donaldson joined CEC in 1957 as an application engineer, and since November had been a field engineer in the Beverly Hills office. Pre-



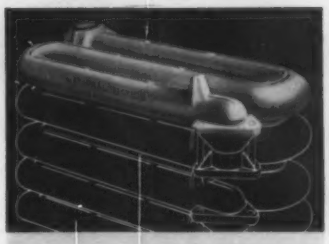
Cast Iron Sections by National-U.S. Cool 400 tons of H_2SO_4 per day

Kermac's new uranium mill makes its own sulphuric acid for leaching ores right at the site, from molten recovery sulphur carried from West Texas by insulated tank truck. The acid plant, designed by Leonard Construction Co., a Monsanto subsidiary, is the largest in the U. S. using recovery sulphur, and yields 98% conversion, sulphur to sulphuric acid.

The sulphur is converted to SO_2 in a sulphur burner, and to SO_3 in a four-pass vanadium pentoxide converter before delivery to an absorption tower for conversion into 99.15% sulphuric acid. Diluted to 93%, the acid is cooled from about 250° to 90° F. in a heat exchanger comprised of National-U.S. Cast Iron Sections before delivery to storage tanks.

National-U.S. Cast Iron Sections are used in most sulphuric acid plants because of their proved resistance to hot, concentrated H_2SO_4; they are easily assembled in any stacking arrangement for the desired total transfer surface area. Their design provides maximum internal and external surface contact for low first cost and high operating efficiency.

If you are interested in heat transfer apparatus for sulphuric acid production or processing, be sure to get in touch with—



Above—National-U.S. Cast Iron Cooling Sections are easily stacked into a unit of any required heat transfer area for sprayed, evaporative or submerged cooling requirements.

Below—This finned internal design increases the surface area and assures proper turbulence for maximum thermal efficiency.

59-13

Heat Transfer Division

National-U.S. Radiator

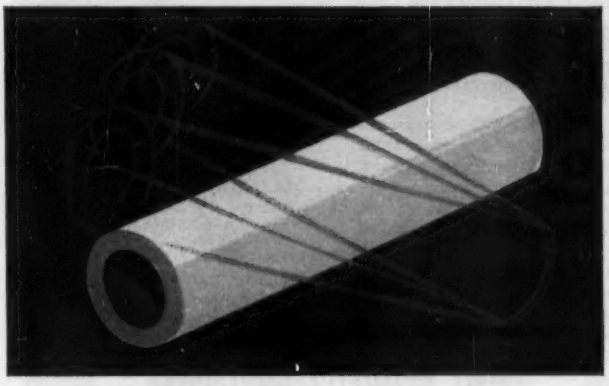
CORPORATION

342 Madison Avenue • New York 17, New York

For more data on advertised products, use Readers' Service Cards, last page.

K&M ZEBRA

THE EXCITING NEW PIPE IN



ZEBRA drops without cracking! This remarkable new insulating material withstands repeated drops up to 17 inches without cracking . . . in increments of 1 inch.

ZEBRA bends without cracking! "K&M" ZEBRA takes a high degree of bending because its deflection at breaking load is four to ten times that of ordinary insulations.

for temperatures of 200°F to 1200°F

Remarkable new "K&M" ZEBRA is a high, medium, and low temperature pipe insulation, available sectionally in a wide variety of pipe sizes and thicknesses.

It has come through with flying colors in tests conducted by both "K&M" engineers and the U.S. Testing Corporation.

These tests prove that "K&M" ZEBRA withstands shock and heat without warping or cracking. It's quick and easy to handle and install . . . with minimum loss due to breakage. In addition, "K&M" ZEBRA meets your requirements for density, conductivity, modulus of rupture, and the ability to withstand soaking heat.

"K&M" ZEBRA is a multi-layer sectional-type thermal insulation primarily composed of calcium silicate-asbestos fiber bonded felts. It's the result of long "K&M" experience in the manufacture of high- and low-pressure insulations, pipe and block insulations, cements, and textiles.

More information on this years-ahead insulating material is now available. Write to us today.

RA

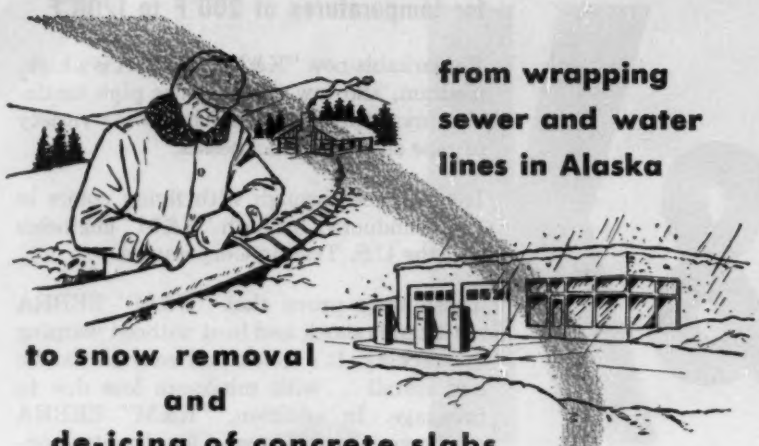
E INSULATION

K·M
BEST IN ASBESTOS

KEASBEY & MATTISON
Company · Ambler · Pennsylvania

ZEBRA **installs in ⅓ the time! Tests prove you can install 2 sections of 3" x 3" "K&M" ZEBRA in only 5.52 minutes as compared to 16.25 minutes for a two-layer segmental construction.**

ZEBRA **won't cause skin irritation! The smooth surface of "K&M" ZEBRA prevents both the irritation of the skin and its penetration by ragged projections.**



from wrapping sewer and water lines in Alaska

to snow removal and de-icing of concrete slabs

to pipe tracing

NELEX HEATER UNITS

Perform efficiently and economically

Nelex Heater Units are literally the heaters of a thousand uses. Since Nelson introduced Nelex Heater Units in 1954, the only limit to their use has been the user's imagination. They have been used to solve countless industrial heating problems. If electricity is available and heat is required, these versatile units can be used.

Most Nelex Heaters are used at present in these two broad categories:

1. Installed on piping to maintain the temperature of process fluids and to prevent liquids in the pipes from freezing.

2. Installed in concrete structures or slabs for the purpose of de-icing and/or snow removal.

Write for Bulletin 1603. This brochure gives you complete information and performance characteristics of Nelex Heater Units.

At Nelson . . . . quality comes first!

NELSON Electric MANUFACTURING CO.
TULSA, OKLAHOMA

Suppliers . . .

viously, he was project manager, Fairchild Aerial Surveys, Inc. He is a member of ISA.

Sedlacek

Schnabel

UNIVERSAL OIL PRODUCTS CO. has assigned three members of its Commercial Development Department as coordinators of sales and licensing activities for specific geographical areas. **C. R. McMahan** will coordinate U.S., Canada, United Kingdom, Continental Europe and Middle East activities. Coordinator for Mexico, Central and South America and Caribbean area is **E. W. Schnabel. W. R. Sedlacek** will serve as coordinator for Australia, Japan and the Far East.

McMahan

ARMOUR INDUSTRIAL CHEMICAL CO.'s John P. Badman has been named manager of highway construction chemicals, with headquarters in Chicago. He joined Armour in 1954 as Southwestern sales representative.

HORACE T. POTTS CO. has been named a distributor of Reynolds Metals Co.'s aluminum pipe. In addition to distributing Reynolds products, Pott's Speedline Fittings Division will use Reynolds aluminum in making its own line of Schedule 10 and Schedule 40 pipe fittings.

THE NEW YORK AIR BRAKE CO. has appointed **John M. Bals** general manager, Aurora Pump Division. Bals has been with Aurora Pump for 15 years, during which he has been export manager, New York branch manager, and division sales manager.

THE STAYTITE CO. has named **C. Andrew Volosin** chief engineer, Houston. A graduate of the University of Houston, he served in the Air Force from 1940-45, and is a member of the American Society of Tool Engineers and ASME.

NORTON CO.'s Dr. Lowell H. Milligan, associate director of research, has retired after 36 years with the company. He has been responsible for many inventions and developments since joining the Worcester, Mass., manufacturer. From 1941-58, Dr. Milligan was in charge of ceramic research on abrasive products and refrac-

For more data on advertised products, use Readers' Service Cards, last page.

STOP!

No Lubrication Ever

with Stockham's new Wedgeplug*

"O-SEAL" VALVE!

It never leaks!

Why is Stockham's new Wedgeplug "O-Seal" valve the hottest thing in the industry? Because it solves your leakage and lubrication problems—for good! It's non-lubricated!!

Here's how the "O-Seal" works—

Two Teflon** "O" rings, inserted in dovetail grooves machined on the face of the plug, seat on the raised body seats when the plug is in closed position. The sealing effect of these rings gives absolute shut-off in all cases—shut-off that **remains permanently "bubble-tight."**

Hundreds of tests of this new valve in all types of services have failed to make it leak. And it never needs lubrication!

RECOMMENDED USAGES . . .

Stockham's new "O-Seal" is recommended for all general services—air, gas, water, steam, propane, hydrocarbons, etc., as well as for hard-to-hold services. Recommended for temperatures from minus 300 F to 400 F and not exceeding 720 psi. • Available in carbon and alloy steels, 2" to 12" sizes, 150 and 300 lb. pressures. Three port openings—40%, 70%, full round. Wrench, handwheel, gear, and motor operated.

Stockham makes a **BETTER** valve . . . for **EVERY** job!

OTHER ADVANTAGES

Provides Double-Block and Bleed in most services • Ends costly maintenance • Double seating for double safety. Ground metal-to-metal seat provides shut-off in case fire burns out "O" rings • Ends product contamination • Protected seats • Quick, easy operation—won't stick or bind.

*Patented **Teflon, Dupont Trademark

STOCKHAM'S NEW WEDGEPLUG "O-SEAL" VALVE

Call Your STOCKHAM Distributor or Sales Representative for complete details, or write today for the new brochure on the Wedgeplug "O-Seal."

WEDGEPLUG VALVE COMPANY

DIVISION OF

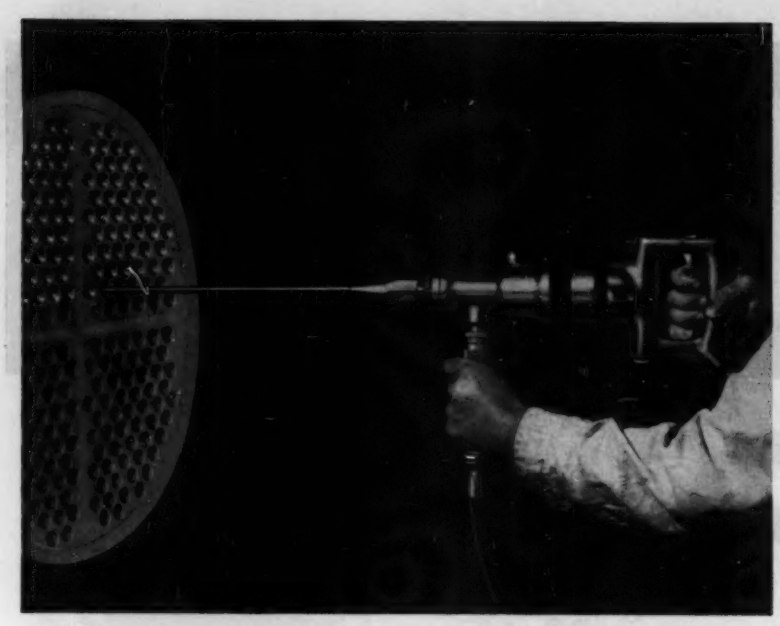
STOCKHAM VALVES and FITTINGS

General Offices and Plant

4003 North 10th Avenue Birmingham 2, Alabama

STOCKHAM VALVES *and* FITTINGS

CAST IRON-MALLEABLE AND DUCTILE IRON PIPE FITTINGS • BRONZE, CAST IRON, DUCTILE IRON, CAST AND FORGED STEEL VALVES



One man handles this powerful Airetool tube cleaner...without a rig

There's no other tool like this Airetool Model CC-475 heat exchanger and condenser tube cleaner. It weighs just 10 lbs. One man handles it easily — without a supporting rig. Yet, it's powerful enough to clean all severely clogged tubes up to 1″ diameter. Built-in flushing system washes away debris, cools drill head — keeps work moving at a fast pace.

You get this same time and cost-saving performance from Airetool straight tube cleaners and pneumatic, as well as electric tube expansion control systems. Write for Bulletin 66. *The Airetool Mfg. Co., Springfield, Ohio*

BRANCH OFFICES:
New York, Chicago, Tulsa, Philadelphia, Houston, Baton Rouge.

REPRESENTATIVES
in principal cities of U.S.A., Canada, Mexico, South America, England, Europe, Puerto Rico, Italy, Japan, Hawaii.

EUROPEAN PLANT:
Vlaardingen, The Netherlands

CANADIAN PLANT:
Brantford, Ontario

Suppliers . . .

tories. During the latter part of this period, he supervised development of these products as well. For the past 18 months, he has been in charge of patents for the Research and Development Department.

Wynn

Tooley

W-K-M DIVISION OF ACF INDUSTRIES, INC., has named **Robert O. Wynn** vice president of engineering and research and **Henry C. Tooley** vice president of manufacturing. Wynn, who has been vice president of manufacturing since 1956, spent the previous six years as head of the W-K-M Engineering Department. Tooley joined W-K-M in May as manager of the Missouri City, Texas, plant. He had been executive vice president of Reed Roller Bit Co., Houston. He is a graduate of Rice Institute and a member of the American Society of Tool Engineers.

OAKITE PRODUCTS, INC., has named **Ben P. Fortin,** a veteran of almost 20 years service formerly assigned to Tyler, Texas, to its Los Angeles staff. **J. G. Hickey** has been transferred from San Francisco, where he has served since 1954, to Sacramento, Calif. **Wayland E. White** has been appointed to the Corpus Christi territory.

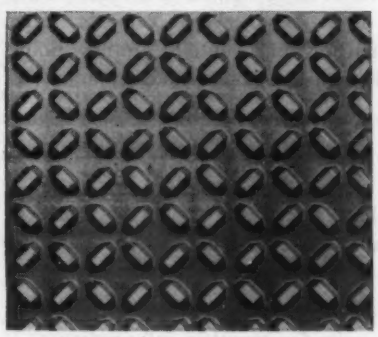
AMERICAN MARC, INC., Inglewood, Calif., has been approved for listing on the American Stock Exchange. Trading in the 3 million shares of the company's common stock is expected to begin within several weeks.

DAVIS ENGINEERING CO. has opened a direct factory sales office at 7256 Touhy Ave., Chicago 48. Manager in charge of the new office is **R. O. Barry.**

DARLING VALVE AND MANUFACTURING CO. has appointed Freile Associates government representatives. Freile Associates, headed by **Ormond Freile,** has specialized in technical and business aspects of government procurement since 1950.

HOOKER CHEMICAL CORP.'s Eastern Chemical Division has named **William L. Gillespie** product manager, organic chemicals, succeeding **Robert B. Boyd,** recently promoted. Gillespie has been manager, sales administration. Succeeding him is **James S. Walker,** formerly manager, technical service. **Lloyd S. Bovier,** formerly administrative assistant to the director of research, has been appointed manager, marketing development, a newly

One slip can cost more than USS Multigrip



Your workers stand—and often fall—in slippery places. Falls account for about 1 in every 5 industrial injuries.

You can eliminate many slips and falls by installing USS Multigrip Floor Plate around machines, on loading platforms, stair treads and main shop aisles.

Multigrip means safe footing wherever it's used. Hundreds of little cleats give safe traction in any direction. Water drains off quickly. Oil and grease can be easily removed with the usual cleaning compounds.

Saves money, too! Where floors take a heavy pounding from traffic, Multigrip will stand up for years. It won't splinter or crack and can be installed in extra wide plates. There's little or no maintenance.

For more information about USS Multigrip Floor Plate, write United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

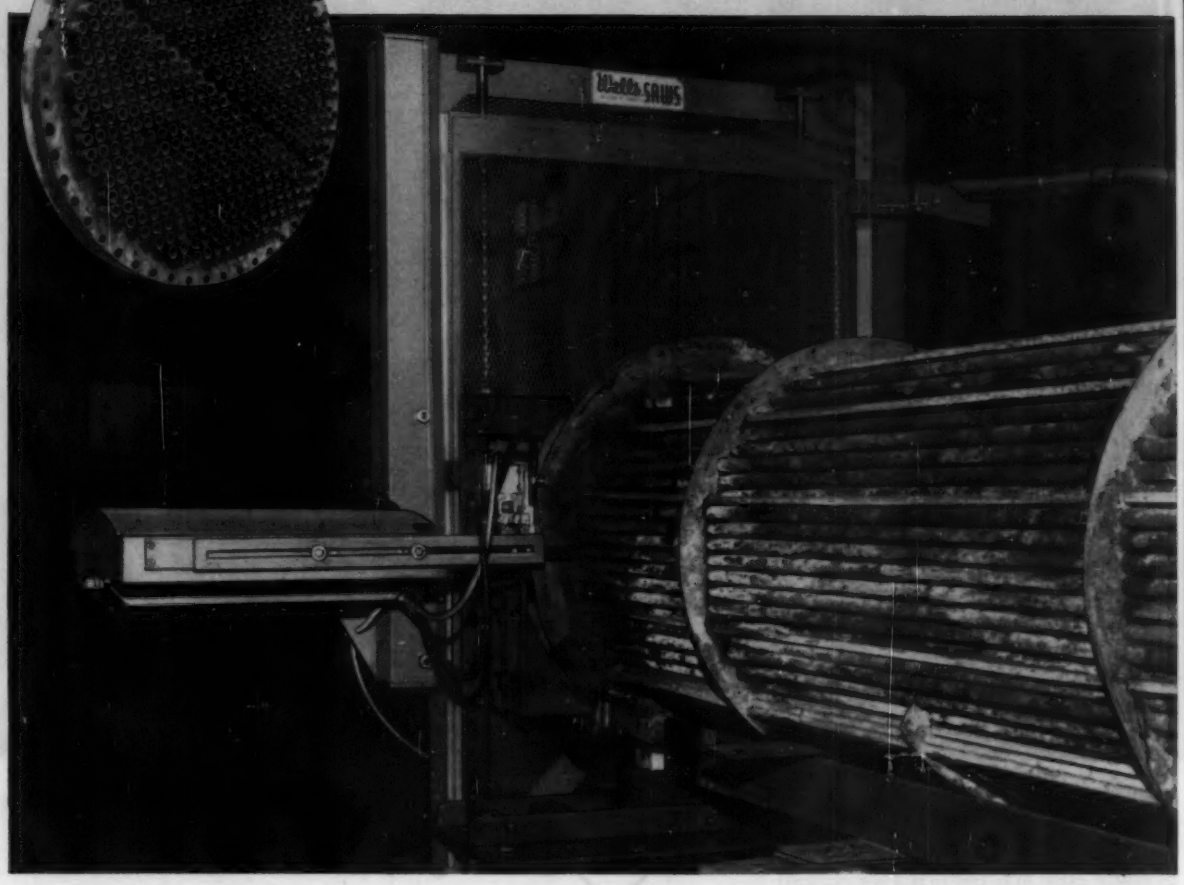
USS is a registered trademark

Sold by leading distributors from coast to coast.

United States Steel Corporation – Pittsburgh
Tennessee Coal & Iron – Fairfield, Alabama
Columbia-Geneva Steel – San Francisco
United States Steel Supply – Steel Service Centers
United States Steel Export Company

United States Steel

Cut Heat Exchanger Tube Bundles
SAFELY . . . QUICKLY . . . CLEANLY . . .
with this
WELLS SAW



TYPICAL OPERATING DATA
(job illustrated above)

Type of Bundle	Debutanizer Condenser
Stationary Head	40½"
Sheet Floating Head	35-11/16"
Head Thickness	3¼"
Type of Material	Brass
Number of Tubes	480
Diameter of Tubes	1"
Gauge of Tubes	14
Type of Material	Copper Nickel
Size of Blades	21'0" x 1¼" x .042"
Teeth per Inch	8
Blade Speed	135 FPM
Cutting Time	165 Minutes

Write for Bulletin SM658 →

This is the Wells Model 12-20G-60 in action. Special Heavy-Duty Cut-Off Machines like this, developed by Wells Manufacturing Corporation, specifically for cutting tube bundles, are now doing the job efficiently in many oil refineries and chemical plants.

Model 12-20G makes safe and easy work of this difficult, hazardous, time consuming job, and materially reduces the cost of heat exchanger maintenance.

Standard models are available for cutting 48" or 60" diameter bundles. J.I.C. electrical standards and modifications of basic design are available to meet individual requirements.

If a safer, more practical, less costly method of cutting tube bundles is of interest to you, write for complete information.

Wells SAWS
Wells

The Pioneers of Horizontal
METAL CUTTING BAND SAWS
WELLS MANUFACTURING CORPORATION
880 Service Road — Three Rivers, Mich.

Suppliers . . .

created post in the division's Sales Department. **Kenneth R. Ewing,** formerly a technical service representative, is now supervisor, trichlorethylene. He succeeds **Stanley A. Mattison,** Hooker's Washington manager.

ALLIED CHEMICAL CORP.'s Barrett Division has named **John W. Bruce, Jr.,** marketing manager, protective products and adhesives. He comes to Barrett from Rubber and Asbestos Corp., Bloomfield, N. J., where he was sales manager. Previously he was with the Industrial Tape Corp., New Brunswick, N. J.

BLAW-KNOX CO., Pittsburgh, has named **Granville M. Read,** retired chief engineer of E. I. du Pont de Nemours & Co., consultant to the president of research, engineering, and development. At Du Pont, he was responsible for design, construction, and engineering research during a period when plant expansion by the company involved upward of $1.7 billion. Read has received the ASME medal for distinguished service in engineering and science, the NSPE award, and "Delaware's Engineer of the Year" award, 1957.

Read

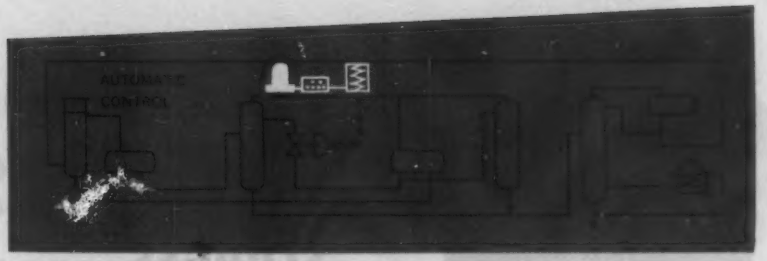
DANIEL ORIFICE FITTING CO. of Houston and Los Angeles has added **Ken Kendall** to its Los Angeles sales force. Before joining Daniel, he was a sales engineer with Rockwell Mfg. Co. for five years. Kendall holds a B.A. degree plus an associate degree in engineering from U.C.L.A.

JONES & LAUGHLIN SUPPLY DIVISION's B. T. Collins, salesman at Laurel, Miss., has been appointed store manager there. He joined J&L in 1952 as a storeman at Laurel, served in the same capacity at the Brookhaven, Miss., store and was promoted to salesman and transferred to Laurel in 1954.

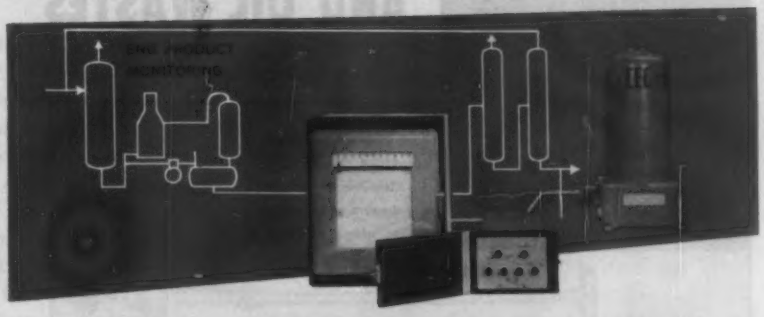
BAILEY METER CO. has appointed **K. R. Dodson** resident engineer, Corpus Christi, Texas, subdivision of the Houston District. Dodson had been on the Houston staff since 1952. He is a graduate of the U.S. Merchant Marine Academy.

ROCKWELL MANUFACTURING CO.'s Meter and Valve Division, Chicago District office, has named **Richard E. Miller** district manager. Miller, who has been manager of industrial meter sales, Petroleum and Industrial Division since 1958, joined Rockwell in 1947 in the Market Research Department.

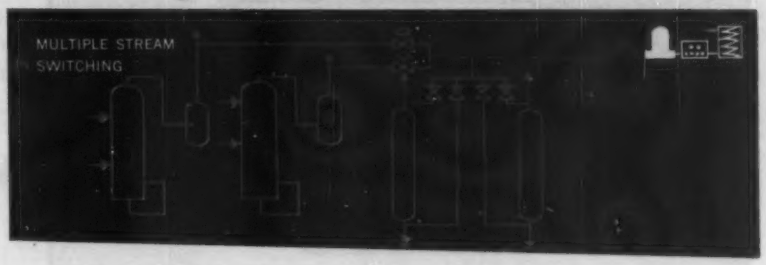
DIAMOND ALKALI CO.'s Chromium Chemicals Division, Cleveland, has named **Andrew M. Roemer,** special staff assistant to the sales manager of the division since 1953, administrative assistant to the



BUY ONLY WHAT YOU NEED . . . *in CEC's*



***modular design* PROCESS CHROMATOGRAPH**



Many streams need a process chromatograph—but few can use identical instruments. To provide a universally adaptable instrument at the lowest cost, all special features of CEC's 26-202 Process Chromatograph are modular. They are built into the instrument to your order . . . *Buy only what you need.*

Modular features available for the 26-202 include: continuous variable attenuation and programming for up to 12 sample components; pre-cutting to shorten analysis time; automatic stream switching and manifolding; automatic zero and zero suppression; multiple column operation; multiple analyzer adaptation; and application to an automatic process control system. *For more information, write for Bulletin CEC 1836C-X 48.*

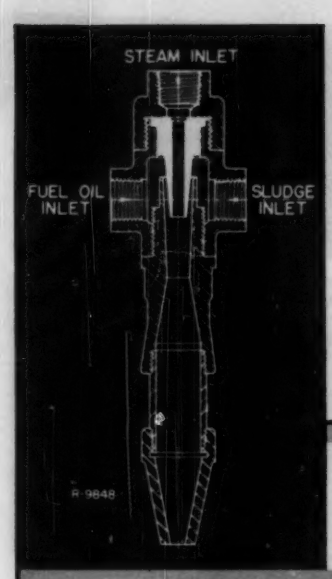
Analytical & Control Instrument Division CEC

CONSOLIDATED ELECTRODYNAMICS / 360 sierra madre villa, pasadena, california

FOR EMPLOYMENT OPPORTUNITIES WITH THIS PROGRESSIVE COMPANY, WRITE DIRECTOR OF PERSONNEL

CEC's LABORATORY CHROMATOGRAPHS—consist of separate control and one or more analyzer units. **26-201A** contains a thermostatted sampling valve with pre-cut column to reduce time for complex analyses. **26-203** features an adjustable temperature range from 50°C. to 500°C., and filament-type detector providing high sensitivity at all temperatures. **Write for Bulletins CEC 1831-X33 and CEC 1847-X13.**

For more data on advertised products, use Readers' Service Cards, last page



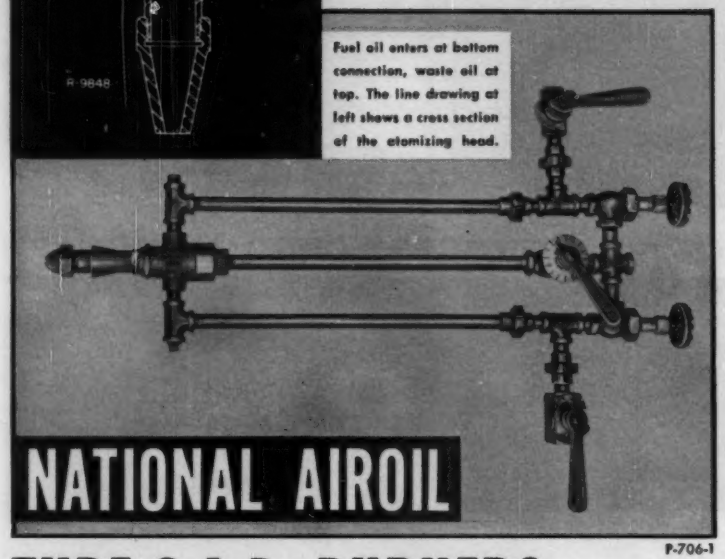
For

CLEAN BURNING

of

SLUDGES AND OIL WASTES

Fuel oil enters at bottom connection, waste oil at top. The line drawing at left shows a cross section of the atomizing head.



NATIONAL AIROIL

P-706-1

TYPE S.A.D. BURNERS

To Atomize by; Steam, Compressed Air or any Fuel Gas under sufficient pressure.

National Airoil Burner Company recommends their patented S. A. D. Burner to improve the disposal of sludges and waste oils in furnaces or open pits in Oil Refineries, Chemical and Industrial Plants.

Type S. A. D. Oil Burners are especially designed for burning acid or caustic oils and their sludges, tank bottoms or semi-liquids of either combustible or semi-combustible nature, the disposal of which generally presents a nuisance problem.

Type S. A. D. Oil Burners will help to quickly burn these materials by admixing them with any needed proportion of regular fuel oil within the burner body and then spraying the emulsified mixture into the furnace.

Type S. A. D. Oil Burners are made standard in sizes 40, 80, and 120 U. S. gallons per hour. Larger sizes special.

Write now, on your business letterhead for Bulletin No. 21, which contains complete details, specifications and illustrations of the Type S. A. D. Oil Burners.

National Airoil

BURNER COMPANY, INC.

Main Office & Factory: 1254 EAST SEDGLEY AVE., PHILADELPHIA 34, PA.

SOUTHWESTERN DIVISION: 2512 SOUTH BOULEVARD, HOUSTON 6, TEXAS

Suppliers . . .

general manager to handle special administrative matters. He will also concentrate on sales, sales administration and continue his work with the company's branch sales offices. **George W. Hottel,** staff assistant to the director of sales, becomes special staff assistant to the division sales manager.

THE C. O. BARTLETT & SNOW CO., Cleveland, has acquired the entire Wettlaufer line of vibrating screens, packing units, blender mixers, granulators and centrifuges. The line was developed by William L. Wettlaufer.

CHICAGO BRIDGE & IRON CO.'s Merwin B. Clapp has been transferred to the company's Chicago district office as a contracting engineer. With CB&I for 13 years, his first assignment was as a design engineer in the Birmingham plant. He was later transferred to the Birmingham sales office and then to general sales in Chicago. Clapp attended Alabama Polytechnic Institute for one year before entering Georgia Institute of Technology where he received a B.S. degree in civil engineering in 1945.

THE DOW CHEMICAL CO. has formed a new Allied Industries group to administer its growing activities in four major markets for coating materials. **L. H. Silvernail** has been named manager of the group, which will be responsible for the company's coatings-technical-service work in the textile, paper, building products and packaging fields.

MALONEY-CRAWFORD TANK AND MANUFACTURING CO., Tulsa, has named **William J. Lank** chief engineer. He has a civil engineering degree from Kansas State Teachers College, and a degree in chemical engineering from the University of Houston. Lank was formerly with the Dallas Tank Co., Dallas, Texas, as a chief engineer.

THE COOPER-BESSEMER CORP., Mount Vernon, Ohio, has named **F. M. Devin** vice president and district manager of a new sales territory known as the East Central District. Working under him are **R. L. Reynolds,** Grove City, Penn., branch manager, **J. R. Craine,** Mount Vernon, Ohio, branch manager and **J. M. Brannaman,** Pittsburgh branch manager.

THE BASSICK CO. has appointed **William W. Gresham,** Greenville, S. C., sales representative in the Southeastern United States. His territory will include South Carolina, parts of North Carolina and Eastern Georgia. Before joining Bassick, Gresham was with the management consulting firm of Henderson, Lindsay & Michaels.

NATIONAL INSULATION MANUFACTURERS ASSOCIATION, New York, has formed an Insulation Information Center for consultation by industry on insulation characteristics, application techniques, and specifications. Located at 441 Lexington

For more data on advertised products, use Readers' Service Cards, last page.

KELLOGG ENGINEERS MASTER THE

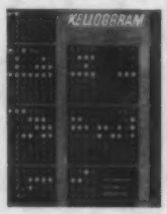
FOURTH DIMENSION

IN REFINERY PROCESS AND PLANT DESIGN

With this high speed digital computer on the staff, time no longer tells Kellogg engineers when their search for better process and mechanical designs should stop. Relieved of the burden of routine computation, engineers can put their creative and professional talents to greater use. Man-hours are more productive. Costs are lower. Above all, every Kellogg client is assured the optimum investment in his future plant.

Now, complex problems that once took days can be completed in minutes, and a greater number of alternative designs may be evaluated in seeking the ultimate. For example, a Kellogg computer study of an existing process examined 19 alternates and rechecked suggested modifications of each. All this ordinarily would have required hundreds of engineering man-hours over a period of about two months. With the computer, only two hours of machine time and few engineering man-hours were required to determine the optimum design.

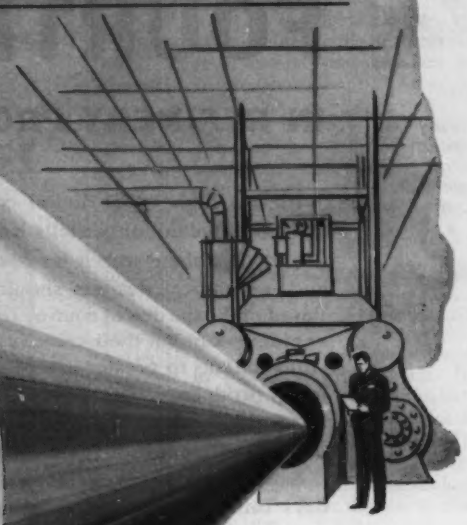
Details on Kellogg's approach to engineering problems with the computer are documented in the current computer Kelloggram, available on request. For an historical review of the company's role in engineering and building oil refineries and chemical plants since 1901, ask for copy of oil centennial Kelloggram.



THE M. W. KELLOGG COMPANY
711 Third Avenue, New York 17, N. Y.
A subsidiary of Pullman Incorporated

Offices of Kellogg subsidiary companies are in Toronto, London, Paris, Rio de Janeiro, Caracas, Buenos Aires

FOR YEARS OF PIPE ECONOMY...



THIS EXTRUDED HEAVY WALL

PROTECTS

against severest heat, pressure and corrosion

Proven in nuclear installations, CURMET high integrity tubing is ideal for the toughest applications in the petro-chemical, petroleum and chemical industries. This tubing from the Metals Processing Division of Curtiss-Wright is extruded in stainless steel and other ferrous alloys in lengths up to 45 feet or more. It provides increased on-the-job life, long term economy based on optimum physical properties—not just for months, but for years to come.

Curtiss-Wright tubing is extruded to specification by the 12,000 ton horizontal steel extrusion press. This process provides uniform high strength and high resistance to pressure, heat and corrosion. Write today for information on both your standard and special requirements.

AVAILABLE FOR DELIVERY NOW
PREMIUM QUALITY STAINLESS AND CHROME-MOLY TUBING

- 8" to 20" OD
- Up to 45 ft. lengths
- ¼" through 4" walls

CURTISS-WRIGHT CORPORATION 70 GRIDER STREET **METALS PROCESSING DIVISION** BUFFALO 15, NEW YORK

Suppliers . . .

Ave., the service will be managed by **John M. Barnhart,** association executive secretary, and **Raymond C. Parlett,** technical adviser and chairman of the Technical and Research Committee.

JONES & LAUGHLIN SUPPLY DIVISION has named **J. J. Hoffman,** salesman at Lake Charles, a store manager there. **R. O. Dulaney,** salesman at Worland, Wyo., becomes store manager for the Worland store.

GRAVER TANK & MANUFACTURING CO. has named **James S. Taylor** and **Wayne Lutke** to posts in the company's oil and gas equipment sales operations. Taylor becomes sales engineer, oil and gas equipment, operating out of Tulsa. Lutke has been named district manager for sales of oil and gas equipment operating out of Midland, Texas.

DATAGRAPHIC SYSTEMS, INC. is boosting its capitalization from $100,000 to $1 million and broadening operations from regional to international scope. President and chief executive officer of the expanded and reorganized company is **Matthew M. Gouger,** vice president and member of the management committee for General Aniline & Film Corp., one of the parent companies.

THOMPSON RAMO WOOLDRIDGE, INC. has acquired Bel Canto Stereophonic Recordings, Inc., a national producer of prerecorded stereo tapes and stereo disc recordings. Bel Canto becomes a third member of the Thompson Ramo Wooldridge Commercial Electronics Group, which includes Bell Sound Division and Dage Television Division.

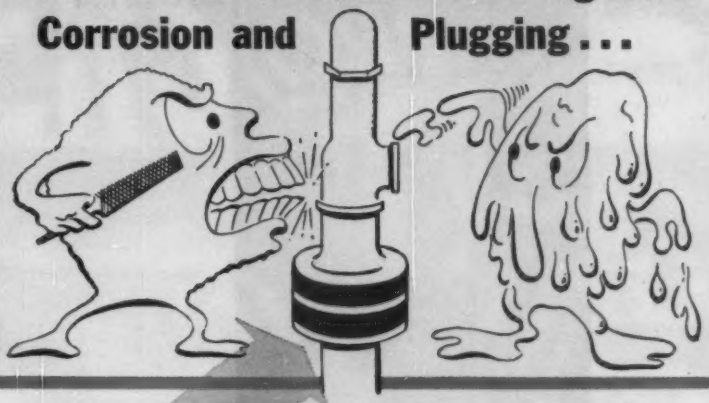
KEASBEY & MATTISON CO. has named **Hodges B. Childs** secretary. With K&M since 1958, he is a graduate of the University of Maryland Law School.

STRAHMAN VALVES INC. has moved from New York to a new plant in Florham Park, N. J. The new factory has increased space, additional equipment and facilities for further expansion in research, design, development and service. The new address is Strahman Valves Inc., Nicolet Ave., Florham Park, N. J.

AETNA BALL AND ROLLER BEARING CO. has named **J. J. Rozner** president. He is also a vice president and member of the board of Parkersburg-Aetna Corp. As executive vice president of Aetna Ball and Roller Bearing, Rozner has directed the company's development program. He was formerly chief engineer, works manager and vice president in charge of operations.

DIAMOND ALKALI CO.'s Soda Products Division, Cleveland, has named **Jack E. Davis,** special staff assistant to the director of sales since March, 1957, special sales assistant for the division. He will assist the manager of industrial alkali sales and become generally familiar with

How To Protect Relief Valves Against Corrosion and Plugging . . .



BS&B *Safety Head* Is A Damage Barrier That Doesn't Change Valve Operating Accuracy

A BS&B Quik-Sert Safety Head mounted to the inlet of a safety or relief valve provides these advantages not otherwise attainable . . .

- Isolates valve from product contamination.
- No product loss as long as the rupture disc remains intact.
- Process or product may be changed without varying valve design or construction.
- Overpressure relief is instant, reaching the valve through wide open, unrestricted orifice.
- Eliminates shut-down time during normal operation.
- Bottle-tight seal during normal operation assures no loss of product.

The absence of a BS&B Safety Head may mean a change of valve construction when process or product is modified. However, with valve mounted above a BS&B Quik-Sert Safety Head the same valve may be used for varying services without alteration. You save the cost of additional equipment. You save the cost of time-consuming valve changes.

If you have a corrosion and plugging problem with your relief valves, call your nearest BS&B Safety Head sales center now. Or write to . . .

BLACK, SIVALLS & BRYSON, INC.

Safety Head Division
Dept. 2-FIO
7500 East 12th Street
Kansas City, Missouri

OVER 60 YEARS — BS&B — ANOTHER EXAMPLE OF PRODUCT LEADERSHIP

Stainless Steel High Pressure Reactor — Fully X-Rayed Seams

IF

Koven MADE... IT'S WELL MADE!

FOR QUALITY CONTROL
- x-ray inspection.
- mass spectrometer testing.
- magnetic particle inspection.
- penetrant dye checking.

80' Diameter Clarifying Tank — Field Erected

Koven equipment in all metals and alloys includes: High pressure vessels built to A.S.M.E. Codes; extractors; mixers; stills; kettles; tanks; stacks; breechings; hot transfer lines; large diameter fabricated piping and plate exhaust ducts; shop and field erected storage tanks.

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Fabrication to all A.S.M.E. Codes

See Sweet's Catalog File and Chemical Engineering Catalog

Call or write for a consultation with a trained KOVEN representative and send for Bulletin #550

Koven FABRICATORS, INC.

Telephone: New Jersey: FOxcroft 6-0400 MArket 3-8150
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93-C East Dickerson Street, Dover, New Jersey

Suppliers . . .

other division sales activities. **Howard M. Berthold,** a field salesman at the company's Pittsburgh sales office for the past six years, transfers to the division to coordinate branch sales efforts with technical service and plant operations in the alkali sales area.

SCOVILL MANUFACTURING CO., Waterbury, Conn., has named **John J. Hoben** vice president and operations manager. A veteran of 30 years service with Scovill, he joined the company in 1929 upon graduating from Yale.

BABCOCK & WILCOX CO.'s Tubular Products Division has named **F. H. Foglesong** manager of alloy sales, with headquarters at the division's general offices, Beaver Falls, Pa. Succeeding him as manager of the division's Detroit District sales office is **A. D. Zar,** who had been sales representative in the Milwaukee district office.

ROBERT W. BLAKE has been elected vice president, sales, Shand and Jurs Co. With the company 22 years, he had been regional vice president in charge of Eastern Sales Region activities.

AMERICAN CYANAMID CO.'s Industrial Chemical Division has named **Richard G. Keppler** sales manager of refinery chemicals. He joined Cyanamid in 1953 as a senior technical representative with the Refinery Chemicals Department, and since has had sales and administrative

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P. O. Box 14, Chautauqua, N. Y.

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Dependable performance in all oil and gas applications

Koppers Piston Rings are now available in the field in a complete range of materials and a wide selection of types and sizes for every application in the oil and gas industry.

To gain trouble-free performance, lower operating costs and less frequent down-time, select Koppers Piston Rings—the choice of many original equipment manufacturers.

Koppers Piston Ring dependability, in even the most rugged applications, is backed with 38 years of experience in manufacturing rings of predictable performance.

If you have a ring problem, consult your Koppers field agent or write: KOPPERS COMPANY, INC., Piston and Sealing Ring Department, 4910 Scott Street, Baltimore 3, Maryland.

Send now for Koppers recommended Piston Ring Set-Ups applicable to the engines which you operate.

KOPPERS Sales Offices and Agents in these convenient locations:

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Dallas 1, Texas

Lynn Elliott Co.
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Houston 2, Texas

Tri-State Industrial
Supply Company
520 Hawkins Way
El Paso, Texas

Nolan Sales Corp.
421 N. Cincinnati St.
Tulsa 20, Oklahoma

D. G. Silvey Co.
316 E. Kings Highway
Shreveport, Louisiana

Sample Bros.
2010 Big Bend Blvd.
St. Louis 17, Missouri

Sample Bros.
6315 Brookside Plaza
Kansas City 13, Missouri

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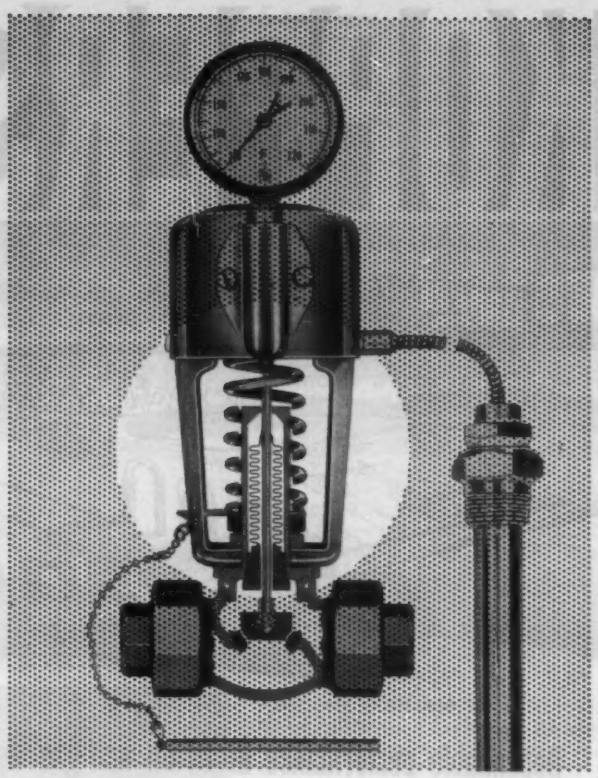
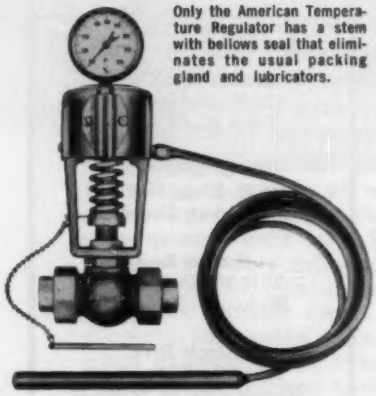
AMERICAN HAMMERED® INDUSTRIAL PISTON RINGS

Engineered Products Sold with *Service*

For more data on advertised products, use Readers' Service Cards, last page.

Temperature Regulation with Corrective Action within 1/10 of a degree





Only the American Temperature Regulator has a stem with bellows seal that eliminates the usual packing gland and lubricators.

A friction-free bellows seals off the valve stem on the new American Temperature Regulator. Result: no stem binding to retard valve action, fastest possible temperature response.

The bellows seal makes practical a friction-free, nonleaking packless valve that needs no lubrication. This innovation plus an extra-long, preflexed adjusting spring marks the new American Temperature Regulator as the fastest acting, most stable available. Corrective action starts at less than 1/10 degree change at the bulb. And the adjusting spring allows unusual latitude in temperature settings.

Compact design permits installation in "tight" locations. The dial thermometer on the indicating-type regulator can be positioned for easiest reading regardless of piping arrangements. Standardized parts and unitized assembly mean low initial cost. Maximum feasible use of stainless steel and a minimum number of components eliminate maintenance problems.

Get the best in economy, accurate temperature regulation, and dependability. Choose American Temperature Regulators. *Sizes:* ½" to 1½". *Temperature Ranges:* As low as minus 15°F. to 50°F.–as high as 240F°. to 350°F. *Valve:* Bronze body, stainless steel seat and disc. *Ask for Bulletin 114A.*

Phone your industrial supply distributor for counsel, service and prompt delivery from his local stocks.

MAXWELL MM&M MANNING & MOORE INC. TRADE MARK

AMERICAN TEMPERATURE REGULATORS

A product of

MANNING, MAXWELL & MOORE, INC.

Consolidated Ashcroft Hancock Division • Stratford, Connecticut
In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario

For more data on advertised products, use Readers' Service Cards, last page.

Suppliers . . .

assignments in both the Houston and Chicago offices. Until his new appointment, Keppler was Western regional manager of refinery chemicals, Chicago. A graduate of Fordham University with a B.S. degree in chemistry, he is a member of ACS, the Chemists Club, American Society of Automotive Engineers and New York Oil Trades Association.

EDWARD VALVES, INC., has named **Rhein Benninghoven** sales representative, Kansas-Missouri-Nebraska area, with offices at 4550 Main St., Kansas City, Mo. He joined Republic in 1929 as a service engineer and was assigned to Kansas City in 1930. Benninghoven recently completed a training course in steel valves at the Edward research laboratories and factory in East Chicago.

CATALIN CORP. OF AMERICA has taken additional office space for its Sales and Advertising Departments at company headquarters, One Park Avenue, New York. The accounting and bookkeeping departments have been moved from Fords, N. J., and integrated into the firm's New York headquarters.

MID-STATES CHEMICAL CO., Mt. Vernon, Ill., has appointed Peck Sales & Service Co. distributor for the Gulf Coast area, with offices at 5822 Harvey Wilson Drive, Houston. Officers of the Peck organization include **Marvin Peck,** president, **Bob Heinrich,** sales engineer and **Milton O'Reilly,** office manager.

U. S. INDUSTRIES, INC., has added to its group of foreign subsidiaries by the formation of a new company in England, called U. S. Industries, Inc. (Great Britain) Ltd. This new European company was established to initially coordinate the European activities of the Clearing and International Divisions.

JEFFERSON CHEMICAL CO. has named **Gerald B. McLeod** to its Houston sales staff. A graduate of Texas A & M College, with a B.S. degree in chemical engineering, he was previously with E. I. du Pont de Nemours, Inc., Victoria, Texas.

THE ENJAY COMPANY, INC. has appointed a new assistant sales manager, Eastern Division manager and Akron District manager. They are, respectively, **J. P. Haworth, H. C. Evans** and **G. H. Lowden.** Haworth, former Eastern Division manager, replaces **P. L. Richards** as assistant sales manager. Evans, former Akron District manager, replaces Haworth, and Lowden, representative in charge of the company's Detroit office, is advanced to Akron District manager.

MONSANTO CHEMICAL CO. plans to develop a research center at its general offices, Creve Coeur, Mo. In the initial phase, a building complex occupying about 400,000 square feet, and consisting of two laboratories and supporting facilities, will be constructed. Utilities and other special services will be provided

If chronic difficulties with packing glands are demanding more than their share of maintenance time, let Allpax prescribe for you. In our complete line of mechanical packings, we are sure to have the remedy you need. If your problem is a special one, Allpax will be happy to diagnose your case and design a special packing for your particular requirement.

Allpax packings cut costly downtime to a minimum, and eliminate undue wear and tear on expensive machinery. Contact your nearest distributor or write to the Allpax Applications Consultant at our factory.

A complete selection of:

- ✔ Teflon* Packings
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*DuPont Trademark

For all your packing needs consult —

ALLPAX

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SEND FOR OUR CATALOG — TODAY!

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CANADIAN DISTRIBUTORS: Albion Asbestos Packings Ltd., Montreal 18, Quebec

For more data on advertised products, use Readers' Service Cards, last page.

Only Grinnell has a complete line of pipe hang

WITH 8 . . . 9 . . . even 10 inches of thermal movement not a bit unusual in today's high temperature piping systems, complete support for piping in all positions of travel is vital.

SAFETY OF ENTIRE SYSTEM AT STAKE

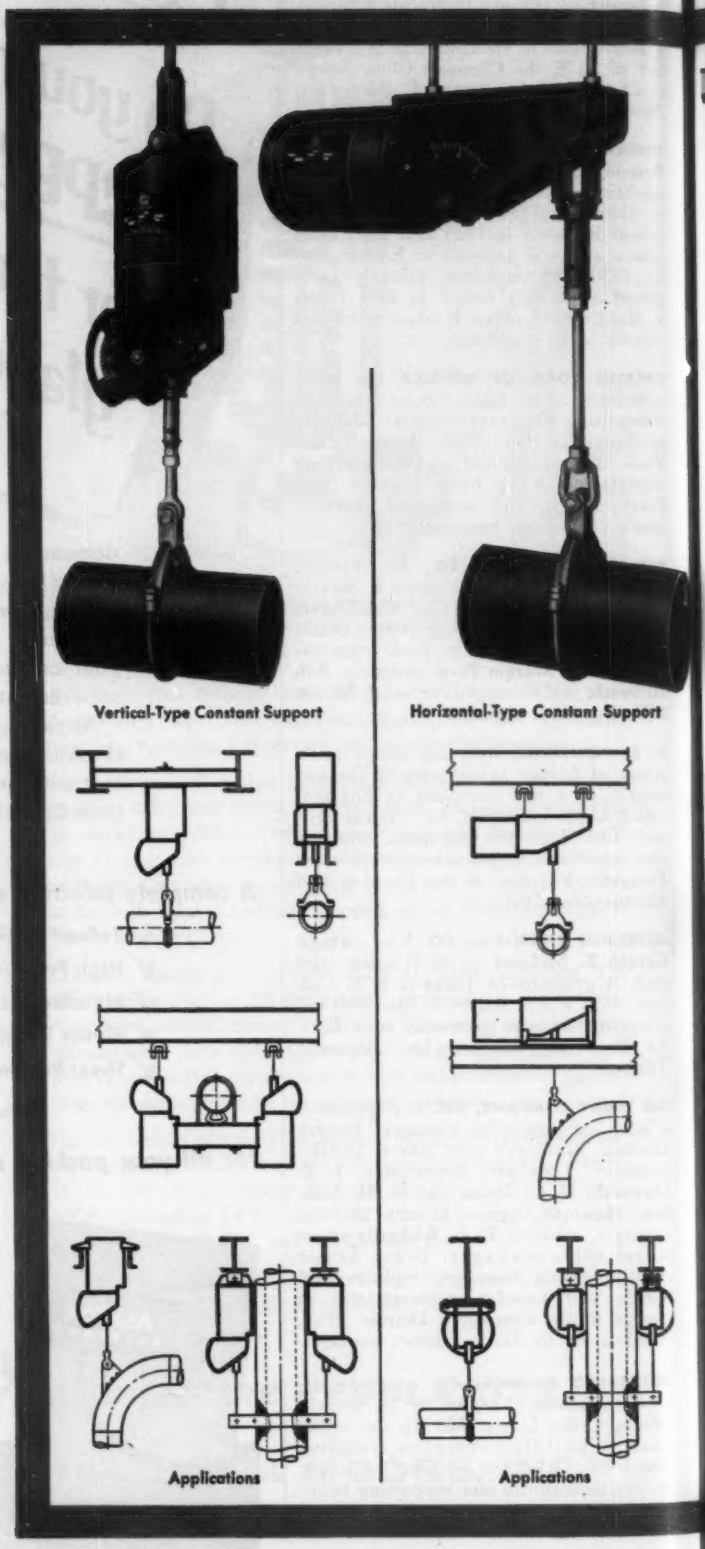
Helical coil springs are widely used to provide for thermal expansion. But the design or selection of flexible supports often is haphazard. Unless careful study is given to the design and choice of spring supports, the transfer of weight from one hanger to another, or from hanger to terminal points, can endanger the safety factor of the entire system.

MATHEMATICALLY PERFECT GRINNELL CONSTANT SUPPORTS

Grinnell Constant Supports are the result of a century of experience in the industrial piping field. A patented geometric design, exclusive with Grinnell Constant Supports, assures mathematically perfect load support throughout all positions of travel. There is also a full 70 percentage points of adjustability built into them. No less than 10 percent of this adjustability is allowed either side of calibration for plus or minus change in load. Field readjustments are easily made by turning a single load adjustment bolt. These hangers are designed to provide uniform supporting force equal to the pipe load throughout the travel range — and should be used at selected points on critical lines, as for example at turbine connections.

Available in 11 Different Types

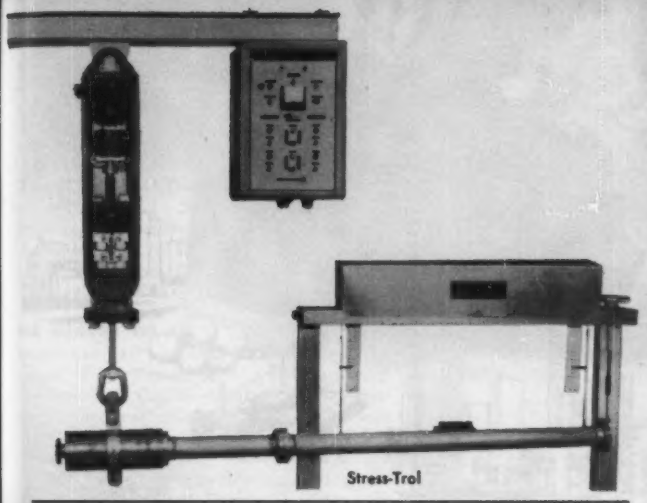
Grinnell Constant Supports are available in eleven types for a complete choice of mounting positions; above, between, or below structural steel. This choice includes both vertical and horizontal design to fit compactly into available headroom space. Even with this wide choice, Grinnell Constant Support Hangers provide mathematically perfect support through *all* ranges of travel, regardless of field adjustments.



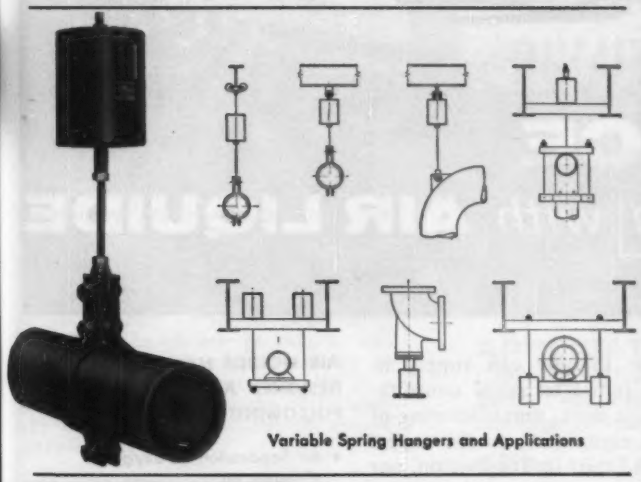
GRINNELL

AMERICA'S No. 1 SUPPLIER OF PIPE HANGERS AND SUPPLIERS

pe hangers to provide for thermal expansion



Stress-Trol



Variable Spring Hangers and Applications

Vibration Control and Sway Brace

Light-Duty Hangers

GRINNELL STRESS-TROL* FOR POSITION AND/OR LOAD CONTROL

Keeping the footage of high pressure-high temperature fabricated piping to a minimum has become important because of high piping costs. This can be accomplished by reducing the length of long expansion bends, but providing support for shorter, less flexible lengths of piping presents a new problem. Grinnell Stress-Trol, a motor operated device, solves this problem. It provides:

Position Control — that minimizes stresses in piping and reactions on connected equipment.

Load Control — that is constant support with unlimited load and travel capacities.

GRINNELL VARIABLE SPRING HANGERS

When pipe lines are subject to relatively small vertical movement, and do not require a constant support type hanger, Grinnell Variable Spring Hangers are available. The maximum variation in supporting force for standard spring models per ½ inch deflection is 10% of rated capacity. Grinnell offers these hangers in 21 sizes — in short, standard and double spring models, plus a special corrosion-resistant model. There are 7 different methods of attachment.

GRINNELL VIBRATION CONTROL AND SWAY BRACE

When necessary to prevent undesirable movement in lines, Grinnell Vibration Controls and Sway Braces of the energy storing and instant-acting counter force type are recommended. They dampen vibration, oppose pipe sway and absorb shock.

GRINNELL LIGHT-DUTY SPRING HANGERS

Finally, simple and inexpensive adjustable light-duty spring hangers often are all that's required to support piping safely. Grinnell has a complete line of light-duty hangers. They are designed for easy installation and quick, accurate alignment of piping.

Whatever your pipe suspension needs, Grinnell can supply them. Grinnell Company, 260 West Exchange Street, Providence 1, Rhode Island.

Patents Applied For

GRINNELL

BRANCH WAREHOUSES AND DISTRIBUTORS IN PRINCIPAL CITIES

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is always on stream with AIR LIQUIDE

If you're planning to build a new plant — to extend — or to rebuild . . . tap this rich stream of low-temperature experience! If it's a question of gas separation or recovery, Air Liquide has the efficient, economical, proven answer.

The Air Liquide stream of experience has been flowing around the world for over half a century. Gaining year by year broader and accurate know-how, it has produced hundreds of low-temperature gas separation plants all over the globe.

Whether you need a plant from an existing design or one especially designed for your particular requirements, Air Liquide can supply it. From the initial technical consultations, design work, manufacturing of plant and equipment, to the expert erection and start-up supervision, our widely experienced Research, Design, and Project teams smoothly coordinate with yours.

We shall be pleased to consult with you in the application of Air Liquide processes and equipment to your particular needs. Write or call us at 405 Lexington Ave., New York 17, N. Y. Telephone: YUkon 6-6544.

AIR LIQUIDE HAVE DESIGNED AND BUILT THE FOLLOWING TYPES OF PLANTS

- Air Separation — oxygen, nitrogen, etc.
- Tonnage Oxygen and Nitrogen (Gas and Liquid)
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- CO_2 Purification
- Methane Purification
- Natural Gas Liquefaction
- Coke-Oven Gas Separation
- Refinery Gas Separation
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AMERICAN
AIR LIQUIDE
ENGINEERING & CONSTRUCTION DIVISION
OLDEST IN EXPERIENCE — NEWEST IN DESIGN

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Suppliers . . .

from two separate structures. The company hopes to have all buildings completed in 1961. The Center will house only laboratory and related activities similar to those already being conducted at the site. There will be no manufacturing or industrial activity involved.

Dr. Wendell P. Metzner, an associate director of research for Monsanto at St. Louis, has been appointed administrative director of the Center. He will direct all supporting activities and services connected with its operation.

ROCKWELL MANUFACTURING CO. has named **Robert C. Neaidengard** controller. Previously headquarters office manager, sales, he will be in charge of the headquarters Accounting, Tax and Systems Departments.

DX SUNRAY OIL CO.'s Marketing Department has named **Edsel F. Eidson** coordinator of sales training. He will be a staff member of the Merchandising Department, general offices. Eidson had been assistant manager of training for Ethyl Corp., and training representative for Shell Oil Co. and other marketing organizations before joining Sunray. He graduated from Oklahoma City University in 1954 with a B.S. degree in marketing, and did graduate work at Louisiana State University.

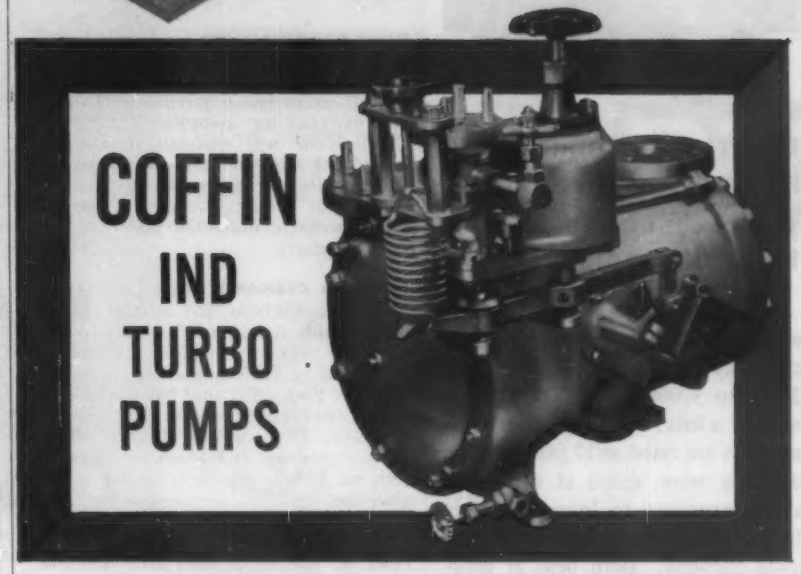
AMERICAN CYANAMID CO.'s Industrial Chemicals Division has named **B. H. Loper** manager of refinery chemicals research. He joined Cyanamid in 1950 at the company's Stamford laboratories and since has held manufacturing, sales, and research posts, primarily in refinery chemicals operations. Before his new appointment, Loper was technical director of the Refinery Chemicals Department, New York. In his new position, he will supervise research programs relating to catalysts and other products. He is a graduate of Illinois Institute of Technology and is active in professional groups, including AIChE.

BENDIX COMPUTER DIVISION, Los Angeles, has named **Gerald E. Hansen** a customer service engineer, Denver. He previously had been with Remington Rand and Rogers Publishing Co. in the Colorado area. Hansen attended the University of Nebraska.

GRAVER TANK & MANUFACTURING CO. has received highest honors of the 1959 Putman Awards for industrial advertising of its elevated water storage tanks. Plaques and prizes of $1,000 each were awarded to **H. J. D'Aragon,** general sales manager, and **Robert F. Millett,** advertising manager, who were primarily responsible for the campaign which brought a substantial increase in inquiries and sales of Graver Tank's water towers.

GENERAL CONTROLS CO. has purchased Wirepots, Ltd., a British manufacturer of potentiometers and dials. To be known

Complete Pump, Turbine and Controls



PACKAGED — integral design of the IND Pump results in a compact, highly efficient unit which mounts impeller and turbine wheel on a short, rigid shaft. The unit is equipped with complete controls for constant or differential pressure regulation.

APPLICATIONS — compact and highly efficient, the Coffin type IND Steam Turbo Pump is designed for General Boiler Feed or any other pumping service where medium volume and high pressure is required.

SPECIFICATIONS-

Capacities	to 180 GPM —	Height 32"
Discharge Pressures	to 350 PSIG —	Width 25"
Liquid Temperatures	to 300°F —	Length 32"

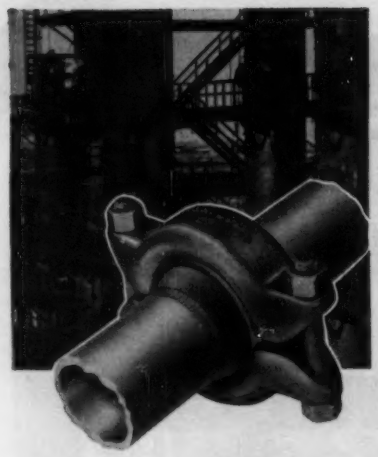
For special installations these ratings may be exceeded.

Coffin Turbo Pump Co.
326 South Dean Street, Englewood, N. J.
Gentlemen: Please send me illustrated booklet further describing the Type "IND" Pump.

Name _____
Position _____
Company _____
Street _____
City _____ Zone ____ State _____

COFFIN TURBO PUMP CO.
FOOD MACHINERY AND CHEMICAL CORPORATION
326 South Dean Street • Englewood, New Jersey
Agents in all Principal Cities • Cable Address: COFCO

For more data on advertised products, use Readers' Service Cards, last page.



GRAYLOC Connections Hold High Pressures With No Leaks During 197,000 Loading Cycles

GRAYLOC connections in use at a Texas chemical plant* were cyclically loaded with pressures from 2,500 to 9,000 psi 197,000 times without a leak. Although these connections are rated at 12,000 psi, two of them were tested at maximum static pressure to learn whether fatigue action had changed the ultimate capacity. Both held at pressures far exceeding rating and one held without leakage to 27,000 psi.

When high pressures are your problem, specify GRAYLOC connections for safety, low initial cost, low maintenance cost. Write for the whole technical GRAYLOC Test Data story today.

*Taken from a letter in our files

GRAY Tool Company

5901

P. O. BOX 2291 HOUSTON, TEXAS
REpublic 4-1641

MAIL THIS COUPON TODAY

GRAY TOOL COMPANY
P. O. Box 2291 Houston, Texas

Please send me the GRAYLOC Test Data.

Name_____

Company_____

Title_____

Address_____

City_____ State_____

Suppliers . . .

as "General Controls, Ltd., an English Corporation," the firm is located at 13/15 Bowlers Croft, Honywood Road, Basildon, Essex, England. Production of the parent company's entire line of potentiometers is being shifted to the British factory.

JONES & LAUGHLIN SUPPLY DIVISION has agreed to distribute Rockwell-Nordstrom plug valves through its stores and sales offices.

FLUOR MAINTENACE, INC. has been awarded a continuous contract by Pabco Division, Fibreboard Paper Products Corp., to supply all maintenance services at Pabco's manufacturing complex, Emeryville, Calif. Fluor will maintain machinery, make tool changes and general repair, and operate electric power facilities for plants that produce building materials, floor coverings, insulation materials and paint products.

AMERICAN CYANAMID CO.'s Industrial Chemicals Division has named **James Boyd Smith** manager of sales development for refinery chemicals. He joined Cyanamid in 1955 as market analyst in the New York office and has served as a sales representative in the Refinery Chemicals Department's Houston office. He is a graduate of Princeton University with an M.S.E. degree in chemical engineering.

JEFFERSON CHEMICAL CO. has named **Peter S. Vail** to its sales staff. He will be assigned to the regional sales office, Chicago. A graduate of Lehigh University with a B.S. degree in chemical engineering he was previously a sales engineer with Celanese Corp. of America.

BLACK, SIVALLS & BRYSON, INC.'s Controls Division has appointed **Jack Kohl** manager, Western Sales Region. He will headquarter at 759 North Highland Ave., Los Angeles. Kohl was previously in Philadelphia as district sales manager. He started with BS&B in 1953 as a sales engineer in the Chicago office.

THE OKONITE CO. has named **C. D. Ham,** formerly factory sales manager, manager of plans, programs, new and special products. **Herbert N. Bush,** formerly assistant to the vice president, marketing, has been named factory sales manager of rubber, plastic and varnished cambric cable products. **Ray J. Wynne,** formerly with splicing materials sales, has been promoted to manager, Tape Department.

NORTON CO. has purchased the inventories, machinery and equipment with drawings, designs and certain other assets of Gould & Eberhardt, Inc., Irvington, N. J. These assets will be moved to Worcester in the near future. Gould & Eberhardt's manufacturing will be continued in Worcester in Norton's machine tool plant. Sales of the Gould & Eberhardt line will be continued through its present distributors.

Choosing an Antioxidant?

DALPAC® 4 SAVES YOU MORE

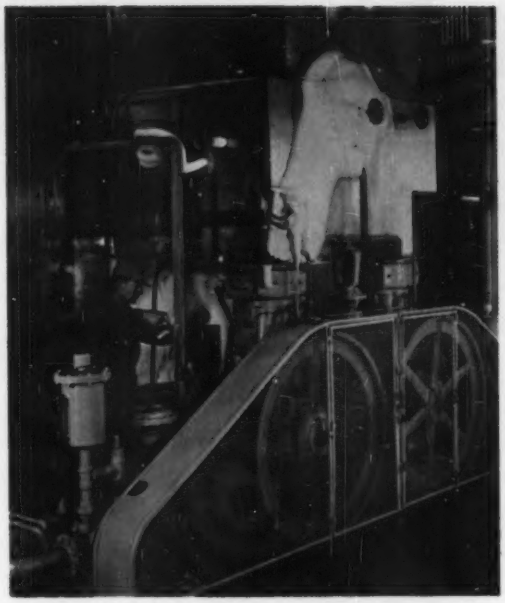
Many refinery customers have found that Dalpac 4 (Hercules di-tert-butyl-p-cresol) saves up to three dollars on every thousand barrels of crude oil processed. Dalpac 4 inhibits gum formation, stabilizes gasoline color, and helps maintain engine cleanliness. Refiners have also found it to be excellent in turbine and transformer oils since it prevents deterioration, and has no effect upon electrical properties.

For additional information write:

Oxychemicals Division
Naval Stores Department
HERCULES POWDER COMPANY
900 Market Street
Wilmington 99, Delaware

NOS9-5

EXPANSION ENGINES TO PRODUCE LIQUID HELIUM AT MINUS 452 F



↑ Vertical single cylinder expansion engines on helium separation service. Hydraulic power absorption system permits quick and accurate response to flow changes.

To build a machine to operate at temperatures just 7.4 degrees above absolute zero requires skill and experience. Temperatures below—400 F are not new to Worthington. Worthington has already engineered expansion engines to operate at—422 F. Worthington has completed extensive engineering work to meet the operational problems encountered at the liquefaction temperature of helium.

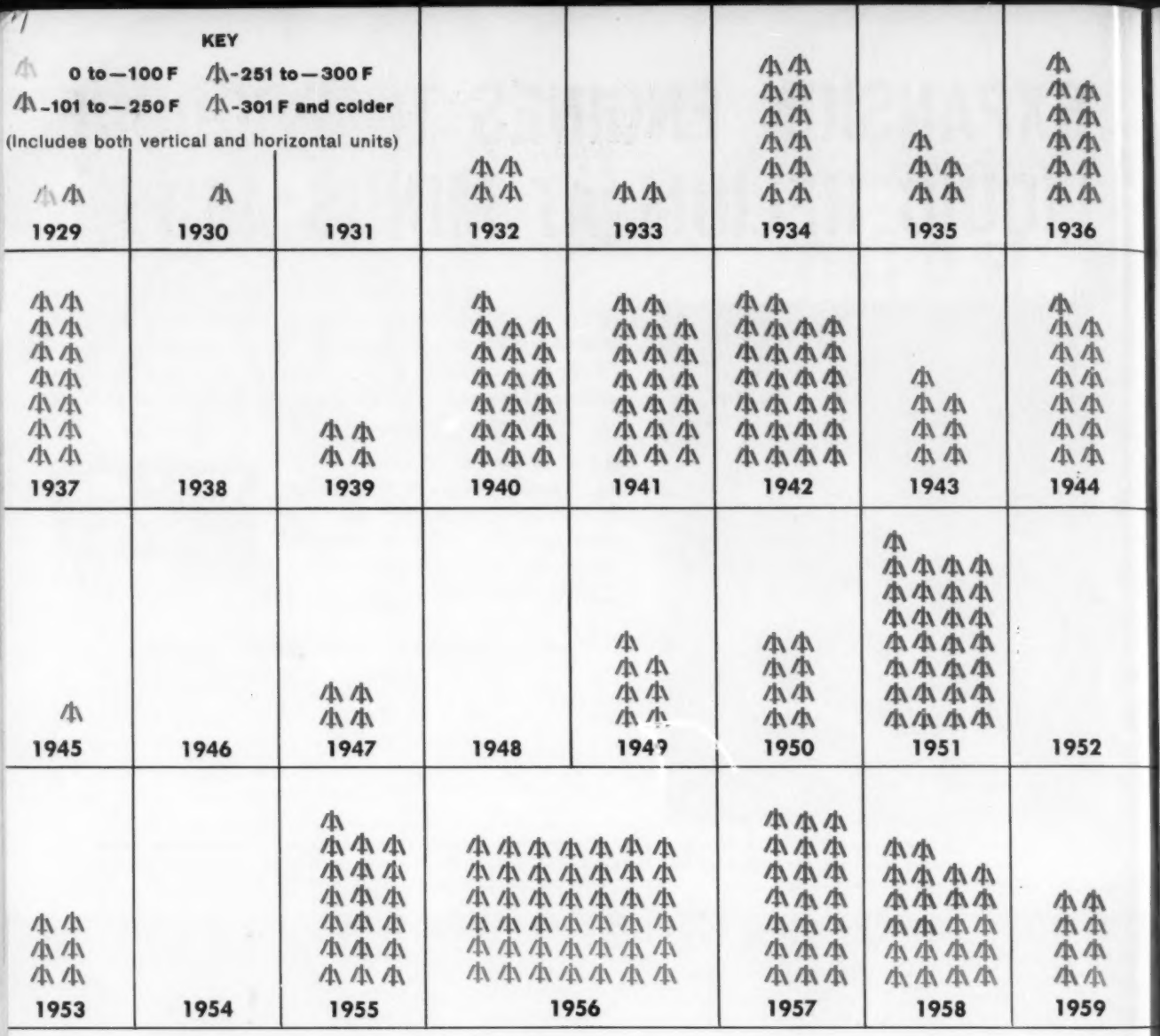
As a natural result of this low temperature work, Worthington now offers reciprocating expansion engines for the demanding job of helium liquefaction. For a documentation of Worthington's experience in the expander field, please turn the page.

WORTHINGTON

Typical applications for Worthington expanders

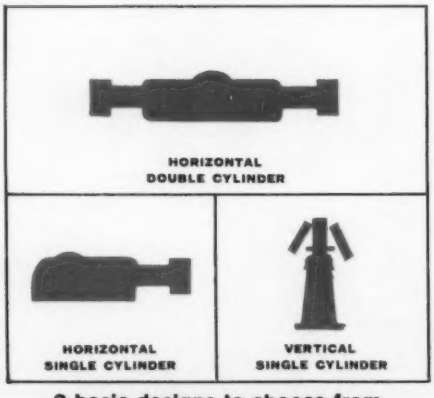
GAS	LIQUEFACTION TEMPERATURE (Atmospheric Pressure)		
	Fahrenheit	Centigrade	Kelvin
METHANE	−258.5	−161.4	111.7
OXYGEN	−297.4	−183.0	90.1
AIR	−317.6	−194.2	78.9
NITROGEN	−320.4	−195.8	77.3
HYDROGEN	−422.9	−252.7	20.4
HELIUM	−452.0	−268.9	4.2

↓ Horizontal single cylinder expansion engine on air separation service. Powerful frame and tough, yet precision valve mechanisms assure high engine reliability.



30 years and 307 expanders later...

WORTHINGTON IS THE WORLD'S LARGEST BUILDER OF LOW-TEMPERATURE RECIPROCATING EXPANSION ENGINES



3 basic designs to choose from

The illustration above pictures Worthington's broad range of experience in the low-temperature reciprocating expander field. (Supplementing this is Worthington's long experience in high and low-temperature turbine expanders.)

An expansion engine is not just a reverse compressor. It must have a powerful frame to handle pressures of several thousand lbs. per sq. in. The valve gear also requires special consideration. Several years ago Worthington developed a patented valve gear with remarkable durability. Operating under loads which sometimes exceed several tons, valve gear failures are almost non-existent.

Many expander applications call for non-lubricated construction. Worthington has successfully built many such units. Worthington also makes all types of units, in both horizontal and vertical designs, to handle every expander application.

Want more information? Send for your copy of a new 8 page expander bulletin. Write to: Worthington Corporation, Section 36-6, Harrison, N. J. In Canada: Worthington (Canada) Ltd., Brantford, Ont.

WORTHINGTON

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A special machinery engineering group within our company is in need of 3 engineers with experience in the analysis, design, development and test of hi-speed centrifugal and turbo compressors, pumps, engines, turbines and heavy duty rotating and reciprocating machinery. Experience in depth in fluid dynamics, stress and vibration is mandatory.

The technical standards of this group are extremely high. The men we seek are now employed and ready for advancement that can be provided by our company as it continues its sound expansion in the engineering, design, manufacture and operation of complete multi-million dollar processing plants in the low-temperature field.

In the Development area a *SENIOR ENGINEER* is desired with a minimum of 10 years' experience in related equipment and with considerable background in supervising and training junior engineers. An *ASSISTANT ENGINEER* with 2 or more years' experience will be selected. We also require a *SENIOR DESIGN ENGINEER* capable of executing major layouts.

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	Magnesia — alumina
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New Equipment & Literature...

Hinged Closures Feature Easy Operation

One-man hinged closures with built-in safety features for vacuum, low and high-pressure service are described in a new brochure just released.

Photographs illustrate one-weld installation, easy maintenance and one-man operation of the new product. Charts give dimensional specifications, and cross-sectional drawings describe design features of various sizes and types. Closures are produced in sizes from 2 through 42 inches for ASA 150, 300 and 600 pound service, with larger sizes and other pressure classes available on special order. Counterbalanced, spring-loaded types are offered for vertical applications in sizes 18 through 36 inches for ASA 150 pound service. Tube Turns.

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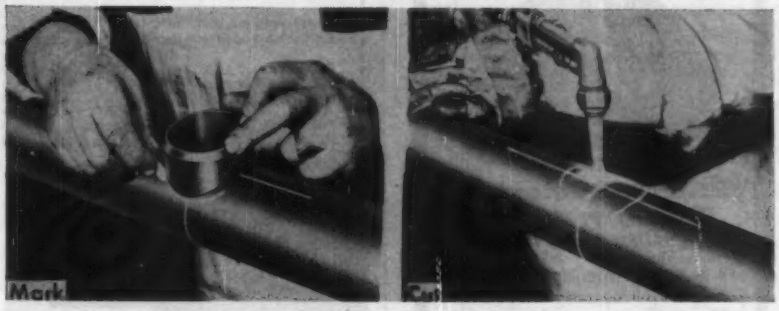
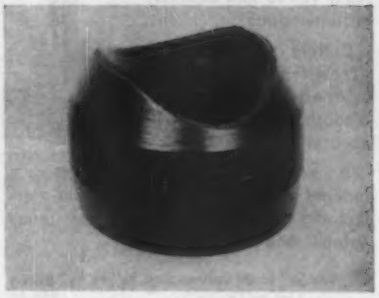


Branch Fittings Replace Butt-Weld Tees

A new high-pressure branch connection fitting has been introduced. Called the W-S TeeLet, the fitting replaces butt-weld flanged malleable iron and forged steel and reducing tees. The fitting is available in sizes from ⅛ through 1½ inches to fit run pipes up to 36 inches. It is available in butt weld, socket weld, or screwed ends. Pressure rating is the same as the 3,000 pound coupling, and no additional supporting calculations are required when used with any A-105 Grade B, Schedule 40 or 80 run pipe.

The TeeLet is a completely machined fitting made from forged quality solid steel bars. The design is such that a root-penetration weld is practically guaranteed even with a novice welder.

The contoured end of the fitting has been designed so that it can fit



more than one size pipe. As such, inventory requirements are greatly reduced to fit all pipe sizes up to 36 inches. H. K. Porter Co.

Circle E2 green card, last page

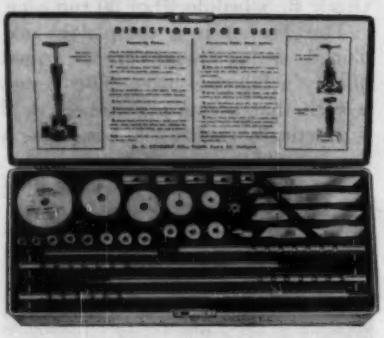
How to Trouble-Shoot Vapor Degreasing Jobs

A newly revised brochure on Trichlorethylene for vapor degreasing is available.

This 36-page free illustrated booklet, is an expanded edition containing important information on Nialk trichlorethylene, a chlorinated solvent characterized by its high degree of purity, uniformity of quality and chemical stability.

A number of features are incorpo-

RESEATS VALVES and BIBBS QUICKLY ECONOMICALLY



Easily pays for itself on the first two jobs!

Reseats flat and tapered-seat globe or angle valves—all bibbs and faucets—in place, quickly and accurately. The saving, over tearing out and renewing leaky valves and fixtures, is tremendous.

Cutters operating under screw feed, leave worn, scored seats glass-smooth, level, absolutely accurate and tight.

A guide pilot centers each cutter; a tapered cone centers each spindle. Perfect alignment is inevitable. Cutters guaranteed. Write for literature!

2" for ⅛" to 2" valves and ¼" to ¾" bibbs
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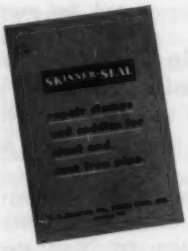

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Equipment . . .

rated in the booklet for the first time. The section specifically devoted to the use of trichlorethylene for vapor degreasing describes operating procedures for degreasing equipment, and the advantages of this cleaning process. Listed are basic cleaning cycles, the quipment for which is illustrated in seven pages of cutaway drawings showing various types of degreasers.

Under "trouble shooting" many practical suggestions are made to prevent or cure commonly encountered operating difficulties. Hooker Chemical Corp.

Circle E3 green card, last page

Hydrostatic Handbook Has 26 Engineering Data Pages

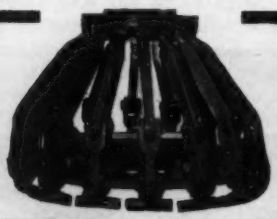
A new 88-page, pocket-size, "Handbook of Hydrostatic Instrumentation," has just been announced. The handbook was prepared specifically for the convenience of engineers and other personnel responsible for the specification, purchase, installation or operation of instruments. Information on the principles of hydrostatic measurement, selection and installation of instruments, design and construction of panel systems, as well as useful engineering data and diagrams have been assembled in a single, handy reference manual.

Twenty-six pages of engineering data are included in the handbook, providing information on tank volume formalae, conversion tables, viscosity charts, hydrometer scales, specific gravity tables for various liquids and other pertinent data. Petrometer Corp.

Circle E4 green card, last page

Slide-Calculator Picks Chemical Service Materials

An unusually detailed calculator, showing preferred materials for 247 different types of corrosives, has just been made available. These handy calculators cover the degree of preference for handling corrosives with aluminum, brass, carbon



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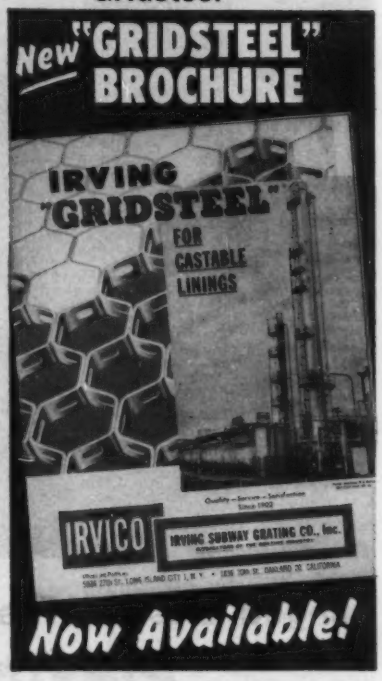

Gridsteel reduces shutdown frequency for repairs of cement linings in pressure vessels when used to armor castables.

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While we're afraid the P.F.I. Standards wouldn't be much use to the moon travelers above, they *are* valuable to you "earth-grounded" readers.

Listed at the left are the technical bulletins that are proving their usefulness to many engineers.

These P.F.I. Standards are packed with vital data on the design, the fabrication and erection of high pressure and high temperature piping used by all industry. However, these technical bulletins do not explain the many advantages of shop fabrication.

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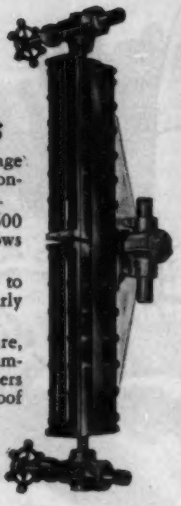

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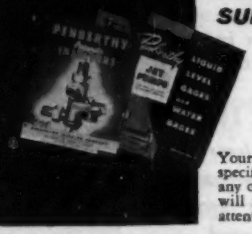

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Equipment . . .

steel, Inconel, Kel-F, monel, nickel, nitril rubber, polyethylene, polyvinyl chloride, 304 stainless steel, 316 stainless steel, 430 stainless steel, Teflon, titanium, and other materials.

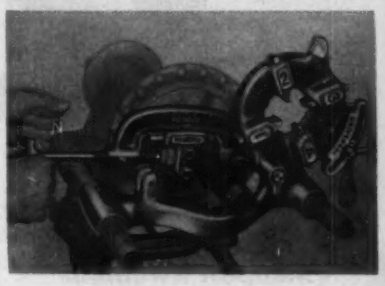
The chart is intended only as a guide to the selection of materials of construction, based on "substantial," "moderate," "questionable" or "inadequate" resistance to the chemical in question at atmospheric pressure and temperature. Also included on the jacket of the slide-rule type calculator is a listing and illustrations of some of the company's fluid control products designed for handling corrosive fluids. These include valves, stainless steel sample cylinders and pressure regulators. Hoke, Inc.

Circle E5 green card, last page

Accessories Convert Power Drive to Pipe Threader

Now, three low-cost accessories immediately convert the versatile, portable 300 Power Drive into a fast, smooth-operating pipe and bolt threading machine.

First of these is the strong, lightweight aluminum No. 310 Carriage, which slips



on the support arms of the power drive, and holds the die head and cutter exactly like a pipe machine. The carriage slides easily—snugs right up to the chuck for close threading and cut-off. Add a No. 19 Nipple Chuck and you can even thread close nipples.

Secondly, there's the new No. 360 Cutter. This full-floating, wheel-type cutter features wide rolls for straight cuts at pipe machine speed. Designed for use with the new No. 310 carriage only, it attaches easily with swivel drive pin.

Finally, the new No. 310 carriage is designed to accommodate any 500 series Quick-Opening Dies—pipe or bolt. A single fine-adjustment screw on carriage aligns each die head for true threads every time. Both die head and cutter operate independently—swing up and stay out of way when not in use. The Ridge Tool Co.

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Mass Flow of Gas Measured Automatically By Computer

An all-electric gas-flow computer for automatically and continuously measuring the mass flow of gas under standard conditions is being marketed.

The basic system consists of a differential pressure transmitter, an absolute temperature sensing device, an absolute

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HIGH ACCURACY AT LOW COST

Power Operated

liquid level

TANK GAUGE

Accurate to better than 1/16".

Readings in feet inches and sixteenths.

Graduations available in metric and decimal.

No floats, counterweights or spring balances.

Large, easy to read numbers on dial and counter.

The *Dynamatic* Power Operated Gauge utilizes a force balance system arranged to detect and display liquid level. The measuring device consists of two elements; a force measuring element and a displacer that is a solid plate of any material suitable to the environmental conditions.

Friction—the specific gravity of the product— the load placed on the gauge head to drive accessory controls and remotes—turbulence—none of these have any adverse effect on the accuracy or reliability of the gauge.

The remarkable low cost and the high level of accuracy and sensitivity have been achieved by Varec's uniqueness of design and not by the sacrifice of quality materials and workmanship. ● *Request Bulletin CP-3705* ●

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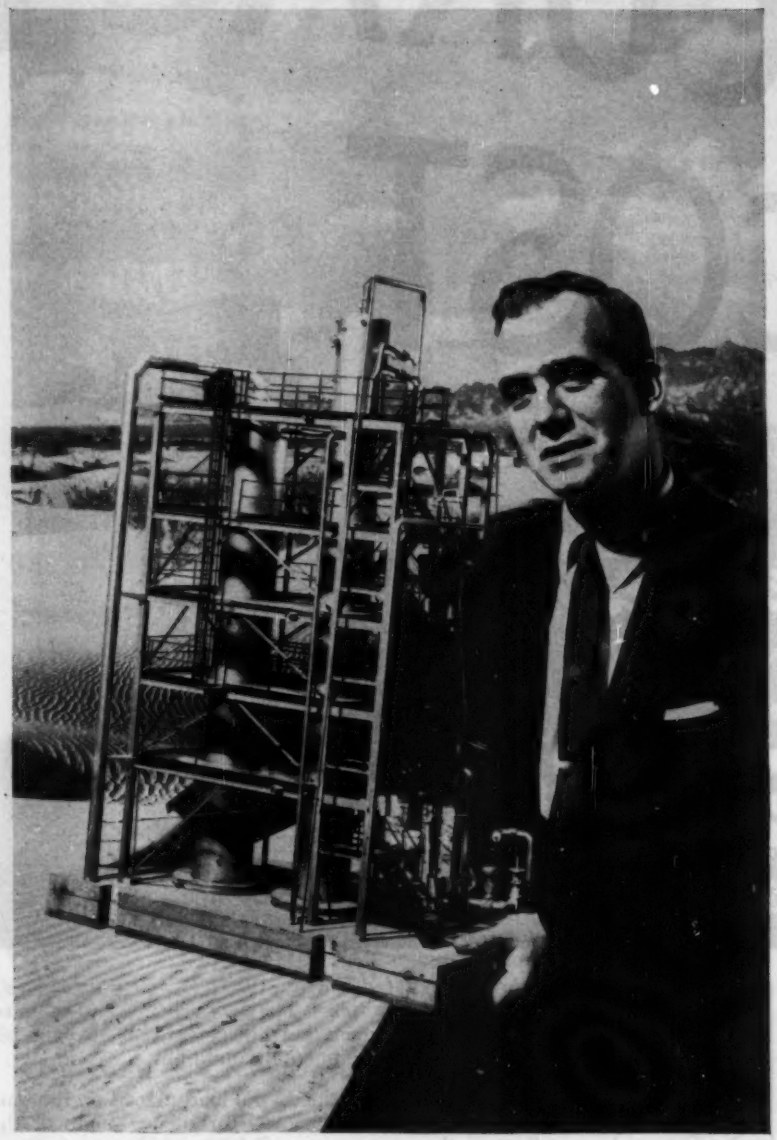

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pressure transmitter, an analog computing circuit, and an electronic circular or strip chart recorder.

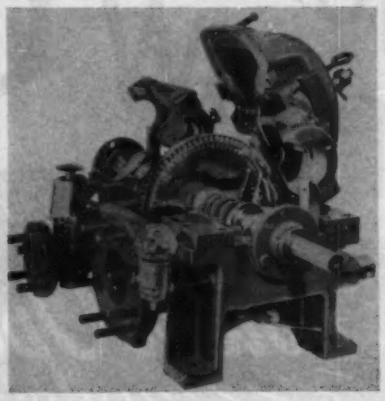
In addition to such functions as indication, recording, control and integration, the gas flow computer can be coupled to telemetering and remote control systems, supervisory control, data handling and industrial process computers.

By continuously correcting the flow measurement for all variables, the system provides the higher accuracy required for economic gas dispatching and accounting procedures. Daily chart changing and manual hourly flow calculations are eliminated. Brown Instrument Div., Minneapolis-Honeywell Regulator Co.

Circle E7 green card, last page

Steam Turbine Minimizes Misalignment Problems

A new Centerline-Mounted Steam Turbine is available with a complete line of frames and wheel diameters for requirements up to 1,000 horsepower, with steam inlet pressures to 875 psig. This single-stage, mechanical-drive turbine is



also adaptable to natural gas expansion and to other gases such as freon.

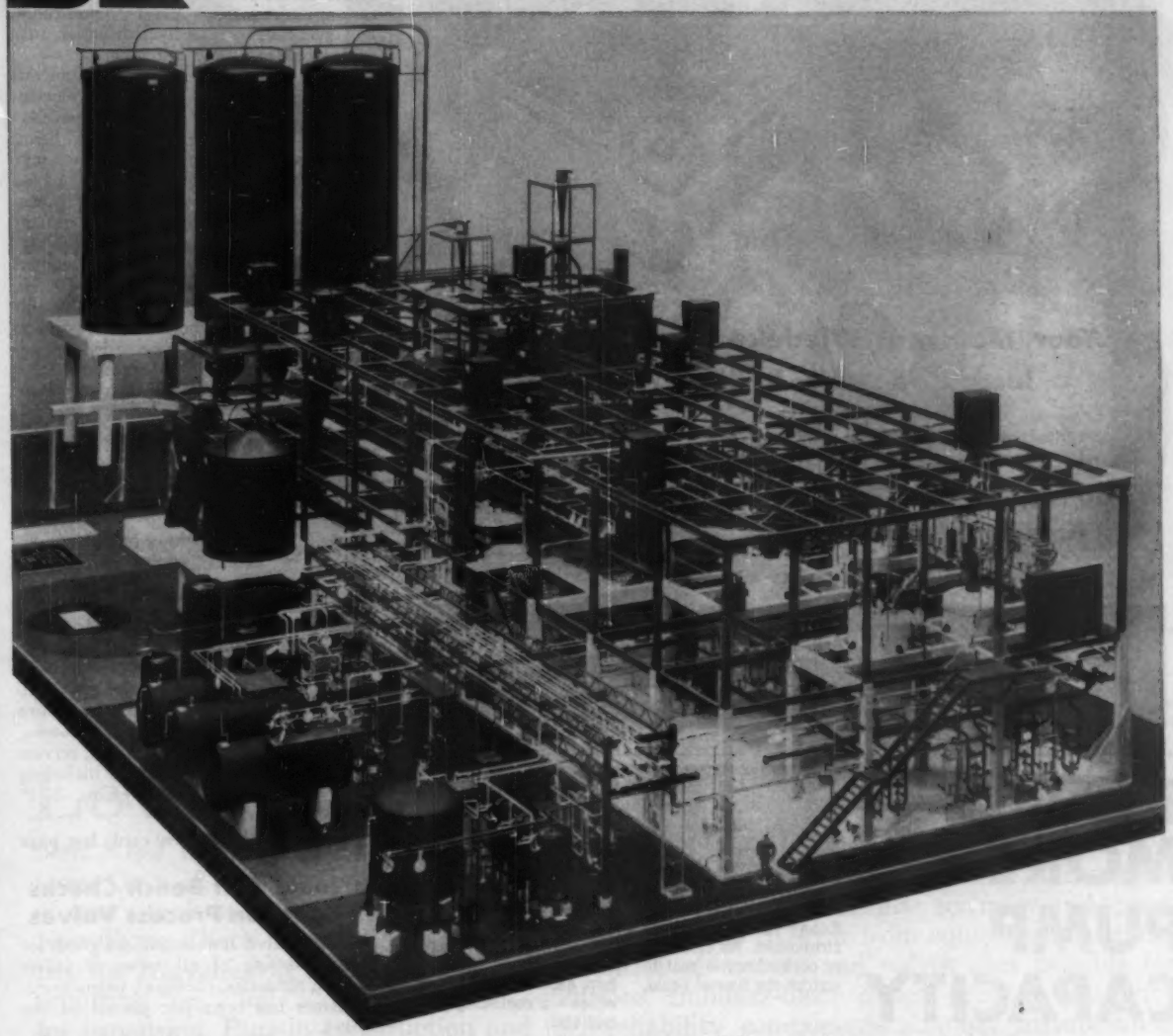
The turbine minimizes problems of radial misalignment between the turbine and the driven machine, usually caused by unequal expansions of metal in the two machines. In this turbine, thermal expansion emanates radially from the shaft centerline. Because the shaft is mounted at points in the same horizontal plane as the shaft centerline, vertical shaft movement is minimized, eliminating the compensations usually required in the support of conventional foot-mounted turbines. The Centerline-Mounted Turbine is supplied to meet all NEMA and API specifications. Dean Hill Pump Co.

Circle E8 green card, last page

Portable Vibration Meter With Laboratory Accuracy

The new model T-1A Vibration Meter is a completely portable, battery powered, transistorized unit furnishing direct readings of the velocity, displacement amplitude and acceleration components

Blaw-Knox designs and builds Cosden's polystyrene plant. Builder of over 90 plastics and resins plants, Blaw-Knox is a leading contractor for this industry's most progressive projects.



Cosden cut pipe installation time by two months with this model

Compared with equivalent projects using conventional design-construction methods, Blaw-Knox's unique model approach builds a plant faster, and at lower cost.

Blaw-Knox makes maximum use of a model as a working tool—to improve visualization, to minimize material and labor costs, and to permit faster field erection without further drafting in the field.

See how this engineering ingenuity can pay off on your next plant or process project. Contact Blaw-Knox Company, Chemical Plants Division with headquarters in Pittsburgh. Branch offices in New York; Haddon Heights, N. J.; Washington, D. C.; Birmingham; Chicago; and San Francisco.

plant builders for industry... BLAW-KNOX

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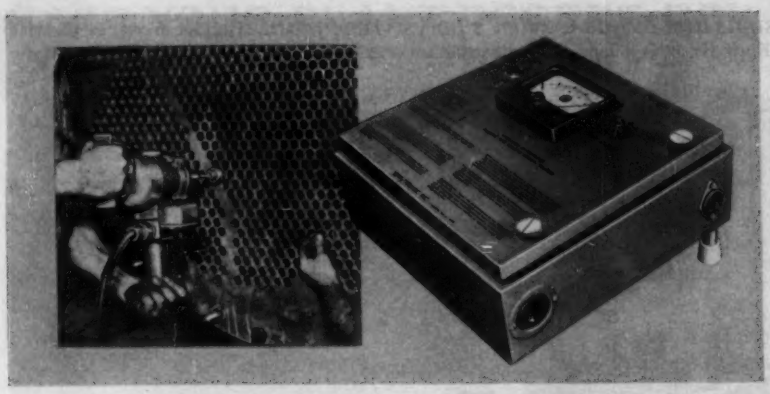

Your Motor + Wiedeke Torque Control = Increased Tube Rolling Production

Save the cost of a new motor! New Torque Control Instrument for rolling ¼" through 4½" tubes in boilers, condensers and similar heat transfer vessels—operates with any Universal Reversible Electric Tube Rolling Tapper or Motor. Adjustable time cycle matches operator's dexterity.

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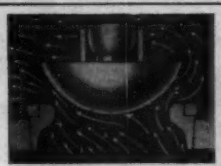
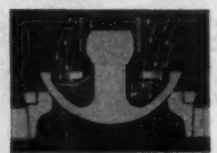
For reciprocating pumps

MORE PUMP CAPACITY ...AT LESS PUMP SPEED with Royal Crown PUMP VALVES



Round valve surface is streamlined. No crossbars or obstructions in seat to restrict the flow of liquid.

Ball-guided valve rotates and swings with each stroke of the pump. Each turn, each swing a lapping action—a continuing perfect seat.



Free vertical action assures instant opening and closing. Ball stem is a frictionless guide.

It's a fact. This revolutionary valve increases pump volume with *less pump speed!* Here's how the Royal Crown Valve operates: Valve is guided by a frictionless ball stem (not a rigid guide) which allows it to oscillate and turn freely with the fluid stream with a minimum of resistance. This means you can pump a greater volume at a slower pump speed for maximum pump efficiency and economy. Royal Crown Valves have only three separate parts which assures long, trouble-free service. They are adaptable to all reciprocating pumps and all liquids.

Write for literature and engineering data.

The Pump Valve with 1000 Seats

EACH TURN
EACH SWING
A PERFECT SEAT

MADSEN WORKS / BALDWIN-LIMA-HAMILTON CORPORATION
CONSTRUCTION EQUIPMENT DIVISION

14120 E. ROSECRANS AVE., P.O. BOX 38, LA MIRADA, CALIFORNIA
BALDWIN-LIMA-HAMILTON CORPORATION, LIMA, OHIO

Equipment . . .

of vibration, and, from a simple computation, its frequency. The T-1A has range and accuracy previously associated only with laboratory-type instruments.

It can accept up to six simultaneous transducer outputs—three for velocity-type pickups, three for crystal accelerometers—one output at a time being selected as desired. From the "Functions" switch, it provides readings of up to 1,000 g acceleration, 0.01-100 in/sec. velocity and 0.001-10-inch displacement at better than 5 percent overall accuracy. Plug-in, high-pass filters may be switched in to remove frequencies below 10, 15, 30, 70, 110, 150 and 200 cps. Output jacks on the T-1A permit it to be used with an oscilloscope or recorder for recording and monitoring vibration waveforms. Southwestern Industrial Electronics Co.

Circle E9 green card, last page

Brochure Covers Selection Of Self-Cleaning Strainers

A new 18-page brochure has been published giving detailed engineering-operating information on the Automatic and Twin Basket Self-Cleaning Strainers. Ranging from pipeline sizes 2 to 48 inches, the strainers will remove suspended particles from all types of liquids.

The brochure covers strainer selection, engineering data on capacities, pressure drop and details of piping connections.

The brochure lists installations, service and size of many installations including refinery and petrochemical plants. S. P. Kinney Engineers, Inc.

Circle E10 green card, last page

Portable Test Bench Checks All Common Process Valves

A new valve test bench designed for pressure testing of all types of valves found in refineries, chemical, petrochemical plants has been just placed on the market.

The valve test bench has two test plates: one for ½ through 2-inch screwed

valves and 8 through 10-inch flanged valves, and one for 2½ through 6-inch flanged valves. Separate controls and gauges are available so that two different valves may be tested at the same time. Special adapters are furnished with each

12345 67890

S & J High Speed Telepulse— Error-Free Remote Reading: Level-Temperature-Pressure

New S & J High Speed Telepulse gives remote readings in English, decimal or metric systems. Only 12 seconds for *complete* gaging cycle, including automatic selection confirmation of user's tank numbers. Other process variables transmitted with similar accuracy and speed. New Error Check circuit makes S & J Telepulse immune to error from equipment malfunction or transmission line failure. Remote control of motors and valves also possible for reporting "on," "off," "open," "closed" conditions. Building-block design provides flexibility for expansion. Plug-in construction and high-reliability components simplify maintenance. 100% digital S & J High Speed Telepulse readily adapted to datalogging and automatic data processing. Write for descriptive technical bulletins.

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2600 EIGHTH STREET • BERKELEY, CALIFORNIA

SHAND AND JURS — GPE GENERAL PRECISION EQUIPMENT CORPORATION

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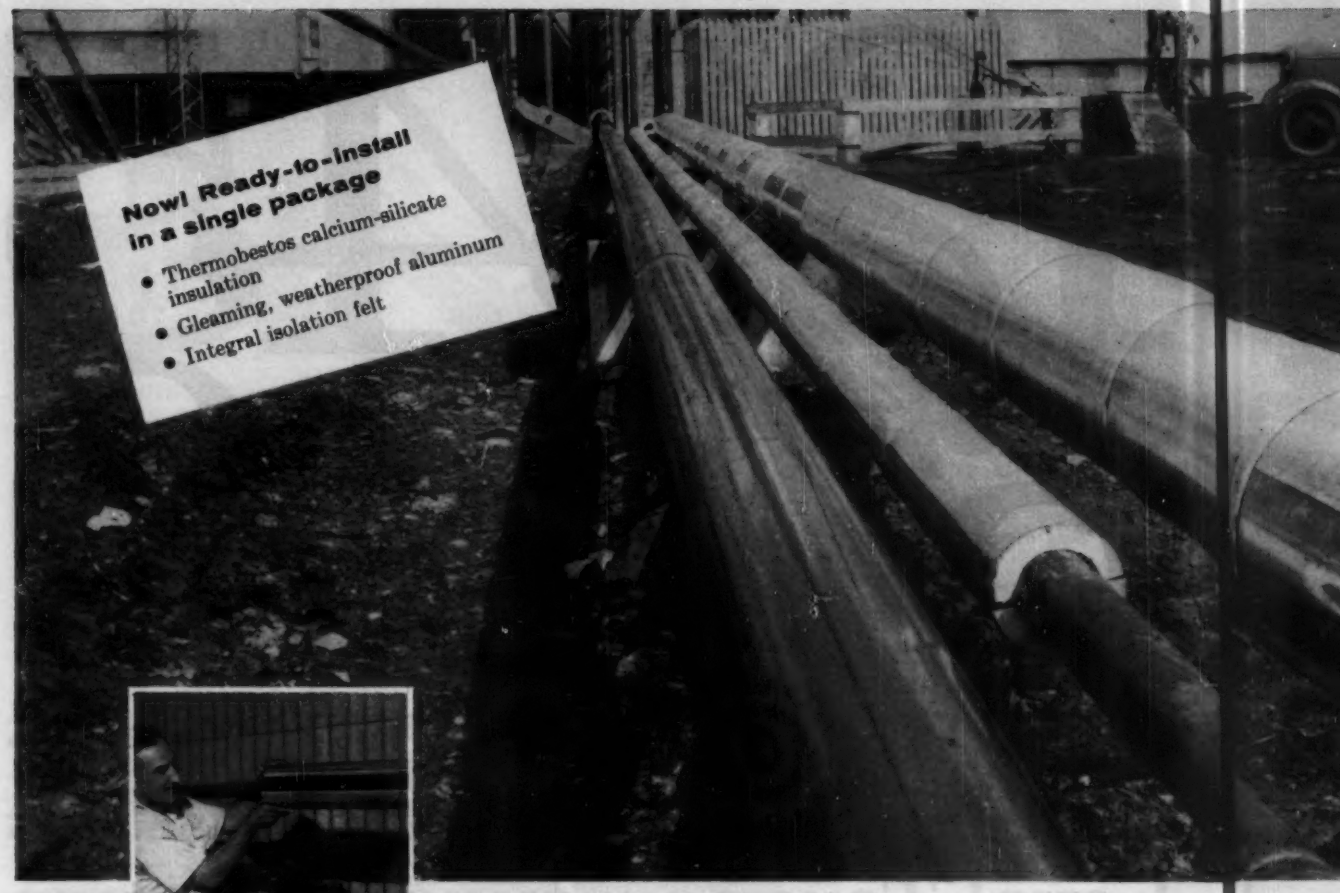
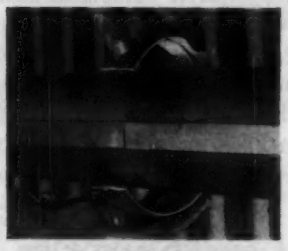

Now! Ready-to-install in a single package
• Thermobestos calcium-silicate insulation
• Gleaming, weatherproof aluminum
• Integral isolation felt

Remove from carton and Metal-On is ready to install. Just snap on pipe and lock in place.



... the specially designed aluminum "snap strap" (containing vapor seal) is snapped on joint...

... Metal band completes the assembly ... provides perfect joint protection against vapor and weather. Available in many colors, the Metal-On band also serves color coding purposes.

Two men completed 660′ Metal-On

New Johns-Manville Metal-On insulation is today's fastest and most efficient way to install high-temperature pipe insulation... and protective metal jacketing

Metal-On is still new! It is just months since its introduction—yet it has already been accepted by virtually every industry in which high-temperature pipe insulation needs protective metal jacketing.

One reason for this rapid, all-out acceptance is Metal-On's installation economy. A single package product that consists of high-temperature insulation and protective aluminum jacket—Metal-On entirely eliminates separate on-the-job metal application. In

Part of 2100-foot Metal-On installation. New plywood plant of the Winton Lumber Co., Jackson, Cal. Insulation Contractor: Western Asbestos Co., San Francisco.

Metal-On pipe insulation presents no fitting problem. It is cut easily right on the job with either power or hacksaws. Available in long, 3-foot sections in a complete range of pipe sizes through 24" . . . by 3" thickness.

this insulation job in one working day!

fact—a section of Metal-On can be applied at least as fast as pipe insulation alone.

However important installation speed may be, it is but one Metal-On advantage! For Metal-On also ends guesswork in specifying aluminum alloys and jacket thicknesses. Its jacket measures an ideal .016" thick . . . of a high-quality aluminum alloy selected expressly for superior weather resistance . . . good appearance . . . and resistance to abuse and pitting.

Of course, Metal-On never needs painting. Won't rust. Is impervious to dirt, oils and grime. And, unlike corrugated metal jacketing, Metal-On has no dirt-collecting grooves—its smooth surface stays clean.

Metal-On also provides top fuel savings and accurate temperature control, because its insulating element is Johns-Manville Thermobestos®, finest of all the calcium silicate insulations for temperatures to 1200F. The conductivity of Thermobestos is lowest of all insulations generally used in power and process industries.

To help you compare Metal-On with the insulation you're now using—let us send you the new technical data brochure, IN-217A. Write for it today. Address Johns-Manville, Box 14, New York 16, N.Y.

JOHNS-MANVILLE

JOHNS-MANVILLE JM PRODUCTS

R-P&C bar stock valves

rugged, compact, economically priced

1. These valves are made from high quality bar stock to withstand high pressure service.

2. Compactly designed, R-P&C Bar Stock Valves are particularly advantageous for close coupled installations in instrument lines or on panel boards.

3. Although designed for control service, the construction of these valves is suitable for general purpose as well.

4. Special techniques, developed by R-P&C for manufacture of Bar Stock Valves, permit these valves to be priced lower than conventional Forged or Cast Steel Valves for similar service.

NOTE: *Valve No. 1070 in ¾" and 1" sizes has renewable seats and discs*

R-P&C Bar Stock Valves are especially recommended for meter, gauge, sampling, or test valves on equipment requiring a reliable, compact valve to withstand high pressure service.

In addition to bar stock valves, our R-P&C distributors offer you a complete line of R-P&C gate, globe and angle valves in all standard materials: bronze, electric furnace iron, cast steel, forged steel... plus specialties for many uses.

See him—or write

R-P&C VALVES

ACCO

R-P&C Valve Division, American Chain & Cable Company, Inc.

Reading, Pa., Atlanta, Boston, Chicago, Denver, Detroit, Houston, New York, Philadelphia, Pittsburgh, San Francisco, Bridgeport, Conn.

Equipment . . .

unit for quick change-over from one size and type of valve to another.

Valves may be tested with either gas or liquid within a pressure range of 0 to 1,000 psi on the standard valve test bench. Units are also available for higher pressures.

The new valve test bench answers a long felt need for a complete, packaged method of testing valves and is the only one of its kind being manufactured as a standard unit. The unit is easily portable and may be used in the field on turnarounds or new construction work. Piping Engineering Co.

Circle E11 green card, last page

Aluminum Pipe Fittings Can Be Butt or Socket Welded

A complete line of aluminum fittings for schedules 10 and 40 pipe has been announced. Alloys include 3003F, 6061-T6, and 6063-T6.

The new line of fittings incorporates the extra length feature familiar to

users of Speedline stainless steel fittings. The extra length gives more clearance for welding, simplifies alignment, allows for flanging without weding, and permits a multiple choice of joint at every connection.

Joints may be butt welded or socket welded with aligning connectors. Either serrated flanges or unions may be used where demountable joints are required. Serrations on the I.D. of both the union ferrule and the flange allow either pipe or fitting to be expanded directly into the union or flange insuring a tight leak proof joint without welding.

Other fittings include tees, crosses, 45 and 90-degree elbows, caps, eccentric and concentric reducers, and stub ends. Horace T. Potts, Co.

Circle E12 green card, last page

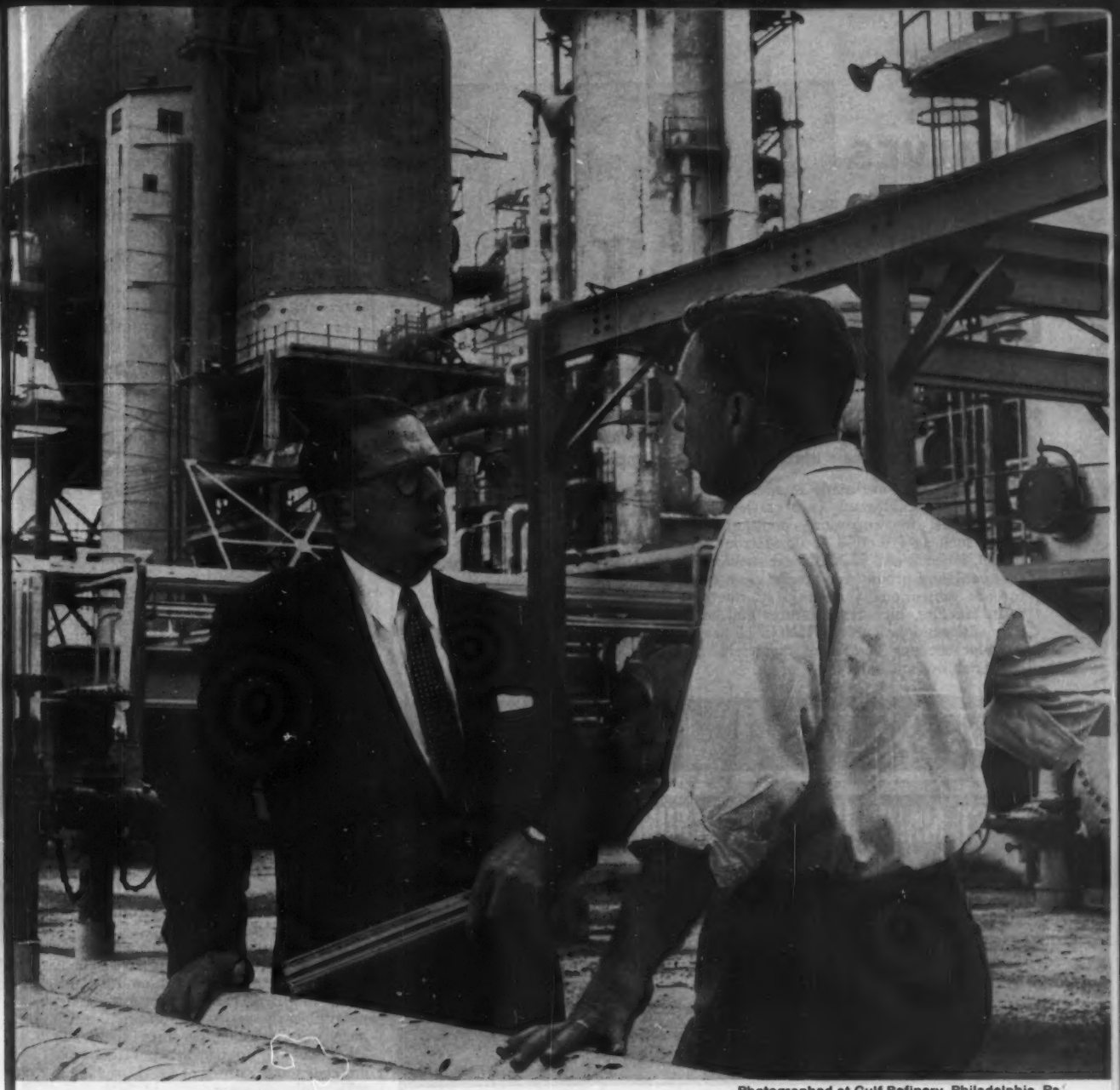
New Gasket Material Is Teflon Impregnated Felt

A new class of gasket materials consisting of "Armalon" TFE-fluorocarbon felts that have been impregnated with "Teflon" TFE-fluorocarbon resin is described in a new technical bulletin.

Properties, potential uses, case histories and availability, together with a table of physical properties, are included in the bulletin.

Impregnated felts of "Teflon" are proving useful as gasketing under extreme conditions.

They will withstand temperatures from



Photographed at Gulf Refinery, Philadelphia, Pa.

How cooperation helped develop a new economy catalyst

Cooperation with refiners at all levels in helping them meet the demand for ever-improved fuels is a guiding principle by which Cyanamid works. This philosophy has aided in the development of many highly efficient catalysts, most recent of which is low-cost Aerocat® 2000 fluid silica alumina cracking catalyst.

Aerocat 2000, compared to natural MS catalysts, offers improved activity stability, higher octane production, superior attrition resistance, more uniform physical properties, and lower coke production.

Cyanamid's sales representatives are prepared to apply the Golden Rule to your problems through the helpful cooperation you want. They are well equipped to be of valuable assistance because of their knowledge and experience in catalytic chemistry, which is backed by a competent organization–a catalyst producer who is also a major chemical manufacturer. Call on your Cyanamid salesman–the man with the Golden Rule.

Basic in catalyst chemistry

CYANAMID

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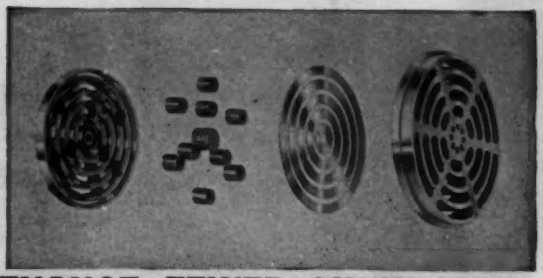
VOSS VALVES

in your machine mean



LESS MAINTENANCE, FEWER SHUTDOWNS

for your compressor. (air, gas, ammonia)

- up to 40% more valve area • minimum pressure loss • higher efficiency
- less power consumption • normal discharge temperature
- quiet, vibration-free • utmost safety • lower operating costs

VOSS VALVES are made to specification, machined from solid stock (not cast)—using best alloy steels; for corrosion condition—stainless steels, such as 410, 18-8 or non-ferrous alloys—monel, inconel, etc. PLATES are machined (not stamped) and ground for precise close tolerance fit; are dimensionally stable . . . ductile . . . resist fracture, high temperatures and corrosion . . . withstand fatigue. SPRINGS of heavy rectangular sections and large diameters, add to dependability and safety.

Our detailed proposal will be sent without obligation. Send name, bore, stroke and speed of machine.

J. H. H. VOSS VALVES
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J. H. H. VOSS Co., Inc.
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MOST MAJOR U.S. PETROLEUM REFINERS REDUCE COSTS with PANALARM ANNUNCIATORS

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Economical, highly flexible design facilitates system expansion. Can be simply adapted to your exact requirement, avoiding costly custom designing. Proven components—e.g., almost 1,000,000 dependable Panalarm developed relays have been used in Panalarm Annunciators.

Ask your nearby Panalarm sales engineer to show you why Universal Series 50 is the petroleum industry's No. 1 annunciator choice . . . how its adaptability and reliability can help increase your profits . . . by producing maximum information and reducing costly downtime. No obligation, of course.

Write for Catalog 100 B today.

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Equipment . . .

below —100° F to +400° F. Capable of withstanding attack by strong acids, they are unaffected by water or any of the common fuels. Since "Teflon" has an extremely low coefficient of friction, felts of "Armalon" may be used as seals and packings in contact with moving parts. Because these materials are relatively soft, they provide durable seals with minimum pressures. E. I. duPont de Nemours & Co.

Circle E13 green card, last page

Detector Converts Pressure Into Electrical Energy

New Resistance Pressure Detectors are available to measure gas, fluid or vapor pressures in combination with the Omniguard monitor. The detector, Model 328 RPD, converts pressure directly to an electrical resistance.

The new pressure detectors are rug-

ged, accurate, reliable yet inexpensive. A wide variety of ranges is available so that low pressures, measured in inches of mercury, to pressures of 3,000 psi can be watched constantly throughout industrial plants on the same Omniguard instruments that monitor critical temperatures. Each alarm pressure can be changed at any time by means of a simple screwdriver adjustment on the front of the monitor.

For pressures under 30 psi, a precision capsule is the sensing element. From 30 to 3,000 psi, special Bourdon tube elements are used. The pressure sensing element linearly varies the terminal resistance of a low temperature coefficient alloy winding to permit operation over ambient temperatures of 32° F to 150° F with minimum error.

The detector is 2 5/16 inches in diameter by 2⅛ inches long, with a ¼-inch stand-

REFRACTORY HAYDITE

Makes Higher Heat Resistant Concrete

Haydite aggregate used with Lumnite cement produces refractory concrete suitable for sustained temperatures up to 1800-2000° F., which makes it excellent for tubular heaters, ducts, flues, stacks and catalytic crackers. Weighing from 30 to 40 per cent less than ordinary aggregate concrete, Haydite is exceedingly strong. It has excellent insulating properties and withstands pressures of up to 1130 pounds per square inch. Write today for free folder and complete information about Carter-Waters Refractory Haydite.

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TAPPING VALVE

U. S. PAT. PENDING

A NEW MEMBER OF A WINNING TEAM!

Designed specifically for temporary use with WmSON Stopple Plugging Machines, Tapping Machines and Lock-O-Ring fittings, the Sandwich Tapping Valve completes the team of WmSON equipment used for tapping and plugging in order to repair or make additions to pipelines or piping without shutdown. Now, after extensive testing in both laboratory and field, the revolutionary Sandwich Tapping Valve is your answer to faster, easier, more economical tapping and stopple work. Faster and easier because it's smaller . . . lighter. Sandwich valves average ¼ as long (face to face) as standard valves . . . allow tapping and plugging in tight places where other equipment is difficult or impossible to use.

NEW! NEW! NEW!

And designed specifically for hot tapping

Plus these outstanding design features

- OVERSIZED BORE
- POSITIVE SHUTOFF
- BYPASS CONNECTION ON EACH VALVE
- INTEGRAL FLANGE STUDS

(Available in 600# series, sizes 4" and larger. Various sizes available for rental.)

For additional information write for Bulletin A-477

T.D. Williamson, Inc.

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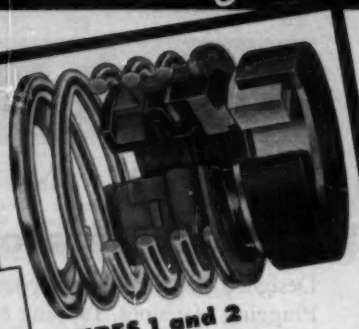
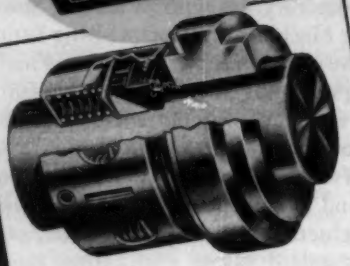
Reduce your liquid handling costs!

Install JOHN CRANE



TYPES 1 and 2
ALCOHOLS
GENERAL CHEMICALS
LIGHT HYDROCARBONS
MANY ACIDS
REFRIGERANTS



TYPE 9
EXPENSIVE CHEMICALS
CORROSIVES
FLAMMABLE LIQUIDS
SOLVENTS
TOXICS

MECHANICAL SEALS

There is no better way to cut liquid handling costs than with "John Crane" Seals. They are specially engineered for the Chemical Industry to provide these important operational savings:

1. **Eliminating loss of expensive and corrosive fluids.**
2. **Positive sealing of toxics, thus minimizing need for costly exhaust equipment.**
3. **Substantially reduced maintenance and the man-hours involved.**
4. **Reduction of "shutdown periods" due to materially increased service-life expectancy over and above your present methods.**

Ranging from the Types 1 and 2 (for services where synthetic rubber is suitable) to the Type 9 (with sealing members made of DuPont Teflon to handle any industrial chemical or corrosive)... there is a "John Crane" Seal that can be adapted to your individual conditions.

remember: **Your toughest problem can be "John Crane's" next success story.**

Don't wait, call us now. Get our seal catalog.....

Crane Packing Co., 6420 Oakton St., Morton Grove, Illinois (Chicago Suburb).
In Canada: Crane Packing Co., Ltd., Hamilton, Ont.

John Crane
CRANE PACKING COMPANY

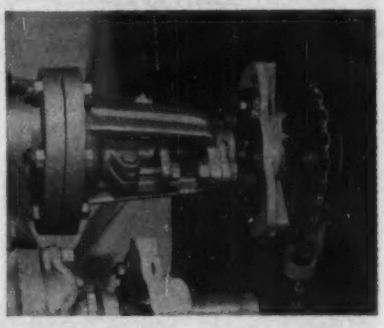
Equipment . . .

ard pipe thread inlet. It is normally mounted in a pressure detector head in order to protect it and the lead wires from damage. McGraw-Edison Co.

Circle E14 green card, last page

Mechanical Hammer Unseats Valves By Impact Action

A faster, easier and more effective mechanical method for the initial unseating and final seating action of a valve in any heat or pressure service has been developed. The unit's hammer and anvil components transfer an impact action to



the elevating mechanism which actuates the valve. Available in both hand and chain-operated models. Whether the impact is hand or chain delivered, only finger-tip effort, without brute strength or wrench, is required on any size valve. Roto Hammer is bolted or clamped to the existing valve handwheel, or the handwheel may be replaced with an adapter where desirable. Featured advantages are:

- Easy, one-man operation at ground level, eliminating expensive and hazardous platforms.
- Positive shut-off which eliminates the possibility of mixing products at manifolds.
- Immediate valve control in any emergency.
- Elimination of accident risks due to chain breakage. The hammer is made in four stock sizes to handle any valve from 2 through 16 inches, and special sizes for larger valves are readily available. Prices range from $32.40 to $72.10. Roto Hammer Co.

Circle E15 green card, last page

Unified Responsibility Is Key to Computer Control

Plans for marketing industry's most complete computer control system for process plants have been announced.

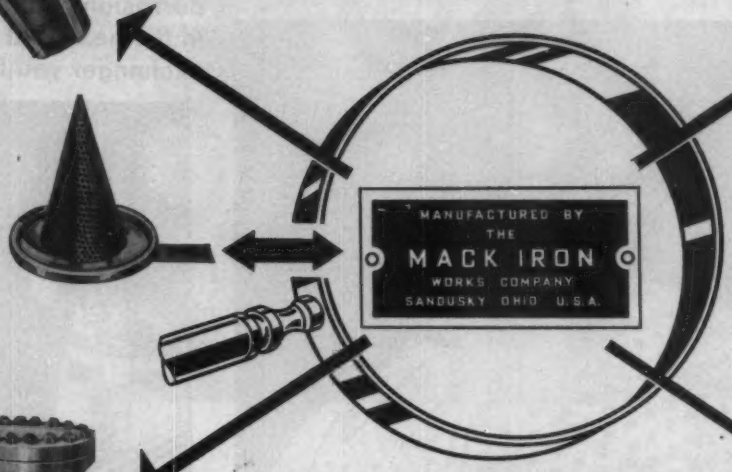
With the 123 system, the company will be prepared to offer management unified responsibility for applying computer control to a process or complete plant.

The major steps in applying computer control to a process are:

- Selecting a process which will benefit economically from computer control.
- Determining instrumentation needed

LITTLE TAG . . . BIG MEANING!

Not a mere name plate, this little metal tag on a piece of equipment is unreserved assurance of quality workmanship and dependability of service . . . *priceless characteristics not solely measured in dollars and cents.*



You'll want Full Line Catalog A-9 for engineering data and specifications.

WRITE or PHONE TODAY!

(Or refer to current **REFINERY CATALOG**)

THE MACK IRON WORKS COMPANY

121 Warren Street, SANDUSKY, OHIO

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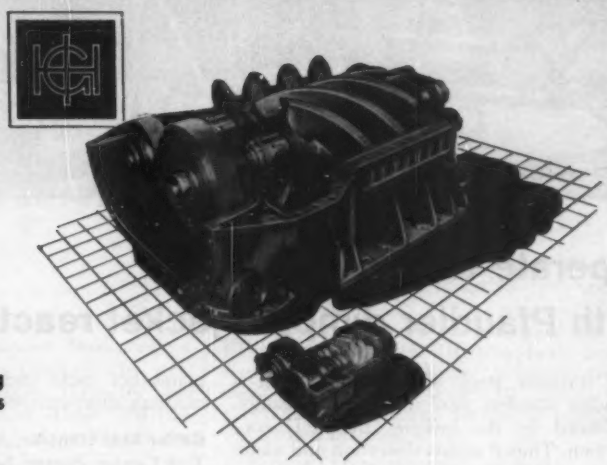
SPECIALISTS TO PETRO-CHEM-REFINING AND CHEM-PROCESS INDUSTRIES SINCE 1901

Stock and custom made items for many engineered applications which involve pumping of fluid materials and operational liquids.

BLINDS • SPACER RINGS • STRAINERS • PIVOT FLANGES

GHH SCREW COMPRESSOR



- **Oil-Free Operation**
- **No Metal-to-Metal Contact of rotating elements**
- **Over 400 Units in Operation handling air, hydrocarbons, and many other gases**
- **Suction Volumes 350 to 15,000 cfm**
- **Compression Ratios up to 1:4 for single stage and 1:10 for two-stage units**

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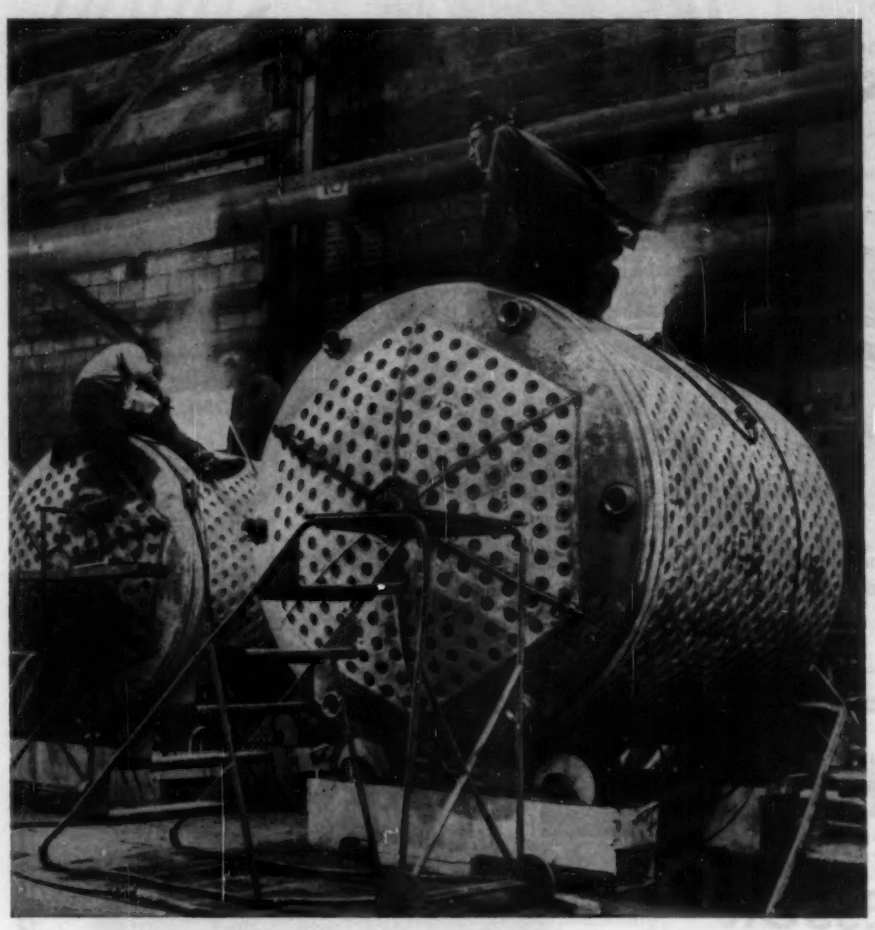
FLUIDICS* AT WORK



Operate to 600° F. with Pfaudler dimpled-jacket reactors

The stainless steel dimpled jacket on a Pfaudler stainless steel reactor is 10-gauge, reinforced by the unique "dimpled" construction. Thus it resists distortion and metal fatigue at high temperatures.

It has a permissible maximum operating temperature of 600°F.—even allows a difference of 450°F. between jacket and vessel contents.

It is code approved for 150-psi jacket pressure. You can get custom designs code approved for 175 psi.

Higher jacket turbulence. Triangular spacing of the dimples interrupts flow of jacket medium and produces maximum turbulence. Baffling further increases velocity, insures complete circulation around the vessel, eliminates hot spots and all possibility of the medium short-circuiting.

Better heat transfer. A study at the Pfaudler Test Center showed heat transfer rates to be significantly greater for dimpled jackets compared to the conventional design.

Costs are lower, too. Savings over conventional jackets are realized at about 750-gallon capacity and/or 100-lb. jacket pressure.

Dimpled jackets are an excellent example of the FLUIDICS program at work. Pfaudler pioneered their use in the process industries, tooled for them, and acquired the know-how.

Complete specifications described in Bulletin No. 944.

How to get 100% corrosion resistance in the next heat exchanger you buy

Pfaudler tantalum bayonet heaters have virtually *zero* corrosion rate in most corrosives at concentrations and temperatures normally encountered in the process industries. The exceptions are hydrofluoric and fuming sulfuric acids and alkalies above pH 8.

We won't recommend one of these heaters if we can't assure you 100% protection.

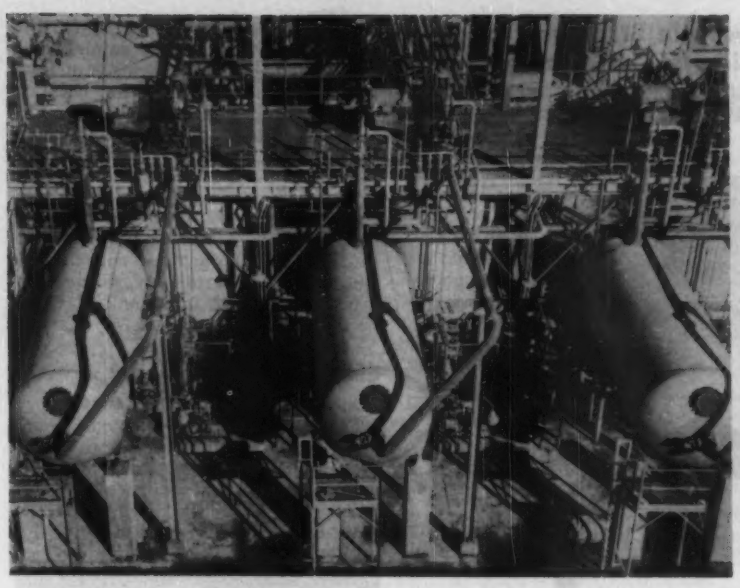
So, in your design figuring, forget about corrosion loss factors. You'll lose nothing to corrosion.

High heat transfer. Since there is no corrosion loss, we can use very thin wall sections. You get extremely high heat transfer rates with no fouling. Also excellent resistance to physical and thermal shocks.

Design: Extremely thin tantalum envelope over inner distributor tube of carbon steel, which serves as steam ejector.

Sizes: 1½" O.D. tubes in lengths to 72" in clusters up to 5 units, offering up to 12 sq. ft. of heat transfer area. Also 2" O.D. tubes in lengths to 84" in clusters up to 4 units with heat transfer areas up to 15 sq. ft. Other sizes on custom order.

New Bulletin No. 978 covers tantalum heaters plus process equipment of titanium and zirconium.



FLUIDICS FIGHTS CORROSION

How Phillips Petroleum saves on equipment for processing natural gas liquids

Phillips Petroleum at Borger, Texas, uses a highly corrosive $AlCl_3$ and HCl catalysis to process natural gas liquids.

The ability of these active chemicals to corrode nonresistant process equipment and to contaminate the product is made even stronger by the high temperature and operating pressure of the process.

Complete Glasteel protection. So wide is the Pfaudler line of process equipment, Phillips was able to select all the following from our standard line: Three Glasteel reactors. Three Glasteel horizontal tanks. Two Glasteel towers. One Glasteel recovery tank.

Problem-free operation. Products have poured out of this plant without any problem of product contamination or Glasteel equipment loss due to corrosion.

Now a second plant — Probably the best proof of Glasteel's success in the process is the fact that Phillips has now built a second plant which is also of Glasteel construction.

The complete line of Glasteel process equipment is included in the *new* Buyer's Guide.

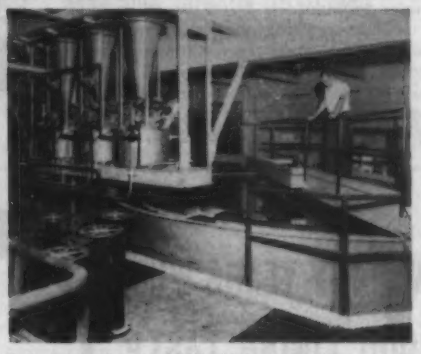
NEW FLUIDICS BUYER'S GUIDE. Get the full story on flow rate control, reactions, heat transfer, fluid analysis, corrosioneering, etc., plus the many products and services offered by the FLUIDICS program. Write for your free copy to our Pfaudler Division, Dept. PR-109, Rochester 3, New York.

*FLUIDICS is a new Pfaudler Permutit program that provides a modern, imaginative approach for handling and processing liquids and gases more profitably.

FLUIDICS UPGRADES FEED WATER PURITY

Why a giant new power plant treats its boiler water

South Carolina Electric and Gas Company draws raw water from nearby Lake Murray for boiler feed in its new Silas C. McMeekin power station.



Bulk impurities in McMeekin's raw water are removed by Permutit Precipitator, which removes turbidity, iron and colorant matter.

The supply is ample, but here's what the water looks like under analysis:

Silica	9.0 ppm
Iron	0.8 ppm
Turbidity	15.0 ppm
Colorants	35.0 ppm
Electrolytes	50.0 ppm

Hardly the sort of water you can feed to a modern boiler. So you'll find a complete array of Permutit equipment at McMeekin. Gilbert Associates, Inc., Reading, Pa., consultants for McMeekin station, reports results from the Permutit system as follows:

Chemical feeders and a 350-gpm precipitator lower iron to 0.2 ppm, turbidity to less than 5 ppm and colorants to 2 ppm.

Three gravity filters further lower turbidity to less than 1 ppm.

Complete dimineralization plant. Permutit anion and cation exchangers reduce the scale-forming silica to an inoffensive .02 ppm, electrolytes to .75 ppm.

Fully automatic control cubicle remotely controls, monitors and records system operation at all times.

Such complete service is typical of the FLUIDICS program. If you have boiler feed water, process water or waste treatment requirements, Permutit offers you everything from initial survey to complete equipment systems.

FLUIDICS AROUND THE WORLD

Pfaudler Permutit is a world-wide company with manufacturing plants in:

Germany	Pfaudler-Werke A.G.
Great Britain	Enamelled Metal Products Corp. Ltd.
Canada	Ideal Welding Co. Ltd.
Mexico	Arteacero-Pfaudler, S.A.
Japan	Shinko-Pfaudler Co., Ltd.

as well as four plants in the U.S.A.

PFAUDLER PERMUTIT INC.
Specialists in FLUIDICS . . . the science of fluid processes

For more data on advertised products, use Readers' Service Cards, last page.

Equipment . . .

(stream analyzers and transducers) to provide necessary process data.

- Installing a 123 Data System to collect data.
- Simulating process by mathematical analog, utilizing data collected.
- Determining size and type of computer required.
- Programming computer and installing equipment necessary for supervisory control or "on-line" control of the process. Beckman/Scientific & Process Instrument Div.

Circle E16 green card, last page

Porcelain Strainer Traps Solids In Chemical Service

A new, all-porcelain strainer especially designed for removing both coarse and fine solids before they enter chemical pumps, valves or other similar process equipment is now available.

The body of the strainer is made of solid chemical porcelain. The unit's end seal is Teflon. Connecting flanges of the strainer are malleable iron and are drilled for 150 ASME bolting, while all other trim is stainless steel.

The strainer element is made of fused porcelain sand providing for chemical resistance and controlled porosity. This element can be easily removed for cleaning or replacement.

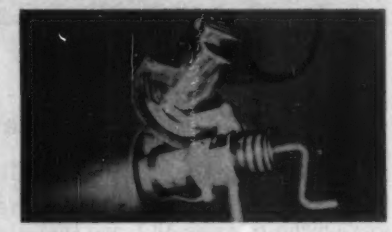
Three strainer elements are available. The coarse strainer element has an average pore diameter of 250 microns; medium strainer has an average pore diameter of 150 microns; and the fine unit has an average pore diameter of 110 microns. Lapp Insulator Co.

Circle E17 green card, last page

Electric Pipe Beveler Assures Precision Lands

Development of a patented electric motor-driven grinding machine to smooth and put the lands on bevels automatically, has just been announced.

The new machine, called the H&M Bevel-Land Grinder is said to be the first



automatic equipment ever developed for this work. It replaces the old, time-consuming method of using a file and hammer, or hand-grinder, to clean and land bevels, assuring uniformity and precision on all jobs.

The Bevel-Land Grinder is available in two models for pipe ranging from 6 to 36 inches in diameter. One model fits 6 to 14-inch pipe and the other handles 14 to 36-inch pipe.

The machine is lightweight and easily portable. It may be locked in place inside the pipe in a matter of seconds, and a simple adjustment in the angle of the grinding wheel is all that is required to change the machine from a cleaning to a landing position.

Use of the new bevel cleaning and grinding machine eliminates all human inaccuracies. It makes possible more positive alignment of pipe and better quality welds by providing cleaner bevels and more perfect lands. H&M Pipe Beveling Machine Co.

Circle E18 green card, last page

High Pressure Compressor Built For Heavy Duty

Rugged, extra heavy construction of the crankcase, crankshaft, and all running gear marks the new Model CJA Balanced/Opposed Process Compressor. Designed for heavy duty applications in the refining, chemical and petrochemical industries, this 11-inch stroke machine is designed for smooth, vibration-free performance and extra long life. Models are built with two, four or six cylinders, and range in size from 400 to 1,750 bhp. Rated speed is 450 rpm with drive fur-

HOW MANY YEARS WILL A GOOD LINING LAST?

Make it with Hexmetal

AND DOUBLE THE NUMBER YOU FIRST THOUGHT OF

A lining lasts as long as its bonding properties.

The natural organic bond of refractory clays and the chemical set of concrete all fail eventually under the stresses imposed upon them. When a lining is "bonded" or given "bone" by Hexmetal Reinforcement, it holds in position long after all its natural bond is burnt out by heat or chemical action. The independent pinned joint of Hexmetal cells give twice the life of other reinforcements with lug joints.

Industry is year by year proving the value of these claims in Flues, Ash-Pits, Reactors, Cyclones, Cat Crackers, Coke Hoppers, Down Comer Pipes, Hydroformers, Water Turbine Flumes, Underground Galleries, etc.

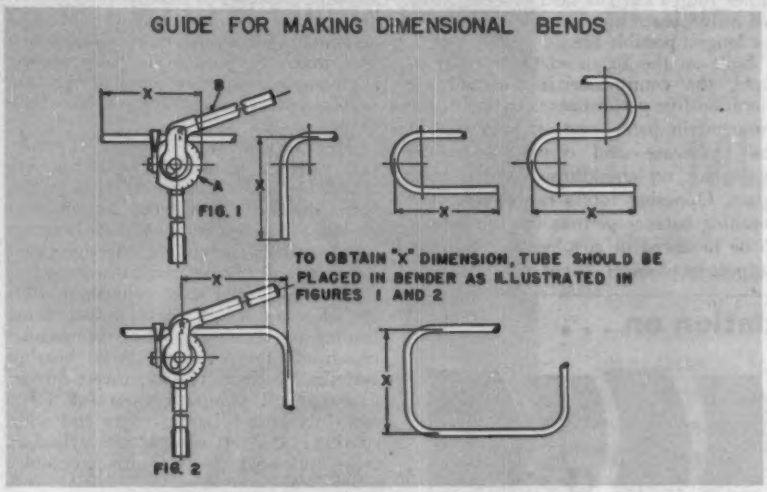
CAUSEWAY REINFORCEMENT LIMITED

Five Ash Works · Dover Road East · Northfleet · Kent

Cables: HEXMETAL, GRAVESEND
Telephone: GRAVESEND 7871/3

IMPERIAL *Engineering and Data File*

ENGINEERED TUBE FITTINGS — VALVES — TUBING TOOLS


GUIDE FOR MAKING DIMENSIONAL BENDS
FIG. 1
TO OBTAIN "X" DIMENSION, TUBE SHOULD BE PLACED IN BENDER AS ILLUSTRATED IN FIGURES 1 AND 2
FIG. 2

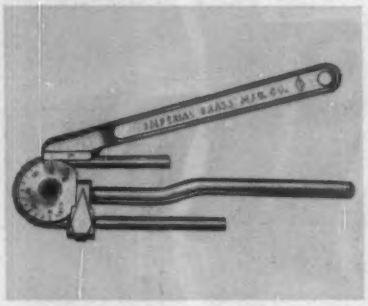
Dimensional tube bends easily made with Imperial Blue Dot Benders

It's no trick to make bends at any desired point — that conform to dimensional requirements as to developed tube length and location — when you use Imperial Blue Dot Benders. Full instructions with each bender.

Imperial Benders are of the open side type. They slip over the tubing where the bend is desired — handy in hard-to-get-at places or when tubing has one end connected.

They form neat, accurate bends on hard or soft tubing without annealing. Calibrated for bending any angle up to 180°.

For complete information on Imperial's complete line of Tube Cutters, Flaring Tools, Sawing Vises, Reaming, Swaging, Pinch-off and Re-facing Tools



. . . write for Bulletin No. 3088 and Hand Book No. 369-B.

Improved bending tools remove danger of installing hazards in tubing systems

Restriction of flow, caused by flattening the tube when making bends, is a common hazard in tubing systems. It retards operation of hydraulic and pneumatic equipment . . . delays signals in instrumentation . . . starves refrigeration systems.

Stress points in bends are a second hazard. These points build up due to scoremarks in the tubing and can result in complete failure under vibration, or under hydraulic surge conditions.

Imperial Tube Benders are specially designed to protect against deformation of the tube, against die marks or other surface imperfections, no matter what type of tubing is being used.

Included in Imperial's full line of tube benders are Blue Dot Individual Benders for ⅛" to ⅞" O.D.; combination benders for 2 to 7 sizes; and Gear-type Benders for ⅜" to 1⅛" O.D. All Imperial Benders will bend hard or soft drawn copper, steel, aluminum, stainless steel, thin wall conduit . . . even aircraft-type stainless steel tubing.

IMPERIAL

THE IMPERIAL BRASS MFG. CO.
6300 W. Howard St., Chicago 48, Illinois
In Canada: 18 Hook Ave., Toronto, Ontario

New high-pressure valves assemble directly to tubing, eliminate additional fittings

A revolutionary new line of Imperial needle valves designed for working pressures up to 5,000 psi., and temperatures to 450° F., employs Hi-Seal tubing connections.

These valves attach directly to tubing and eliminate additional fittings. This not only reduces cost but cuts installation time and eliminates principal source of leakage. For low pressure service, Imperial also supplies a complete line of fluid control valves in diaphragm, plug, (2, 3, and 4-way styles) — needle and toggle types.

Write for Bulletin 3096, or Catalog No. 200

Flare quality vital to making tight 37° flare fitting joints

The quality of a 37° Flared Fitting Joint is no better than the quality of the flare that has been made on the tubing. Even the finest fitting will fail if the flare isn't right.

Experience of countless users has demonstrated this on jobs of all types.

Flares that are rolled-in-the-air, instead of being formed against the die block, are a big aid to better joints. Wall thickness of tube is retained without thinning at its vital point — the base — to assure a far stronger flare.

Imperial 37° Flaring Tools in several models offer this feature. In addition, burnishing action that assures a smooth, true surface — so important to a tight joint — is provided by a special device in the feed mechanism. The Imperial line includes 37° Flaring Tools for tubing in all metals, sizes 3/16" to 2" O.D.

Imperial also offers a complete line of 37° Flare Fittings in brass, steel and stainless steel.

Write for Catalog No. 200.

CONTACT YOUR INDUSTRIAL DISTRIBUTOR OR WRITE TO:

IMPERIAL BRASS MFG. CO.
Dept. PR-109, 6300 W. Howard St.
Chicago 48, Illinois

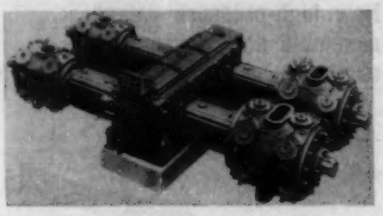
Please rush me:
Bulletins ☐ No. 3040 ☐ No. 3088 ☐ No. 200 ☐ No. 369-B

Name.....
Title.....
Company.....
Street.....
City..... Zone... State.....

For more data on advertised products, use Readers' Service Cards, last page.

nished by an electric motor, or other types of prime movers.

Ideal for high operating and high differential pressures, the Model CJA can be equipped with a wide variety of



compressor cylinders in an almost unlimited number of sizes. This flexible design feature permits assembly of machines to handle pressures from vacuum to 35,000 psi.

For the majority of applications, compressor valves are of the multiple ring type, precision cast of nodular iron to assure smooth surface and minimum resistance to gas flow. For high operating pressures, valves can be furnished in either forged carbon steel or alloy steel. All valve seats are induction hardened for longest possible life.

Built on the Balanced/Opposed principle, the compressor is designed for vibration-free performance. Cylinders are mounted in pairs—one on each side of the crankcase—and connected to the crankshaft on crankthrows 180 degrees apart. Opposing forces cancel out. The resulting balance permits the compressor to be mounted in any location that can support its physical weight.

For greater simplicity and freedom from alignment problems, the compressor features overhung rotor construction. Extra bearings in the compressor crankcase allows the rotor to be mounted directly on the crankshaft. Outboard bearings and flywheel are eliminated, installation is simplified (the only field line-up required is stator rotor), and floor space requirements are cut to a minimum. Overhung rotor construction also makes it possible to fully enclose the one-piece collector rings of synchronous motors when operating in hazardous areas.

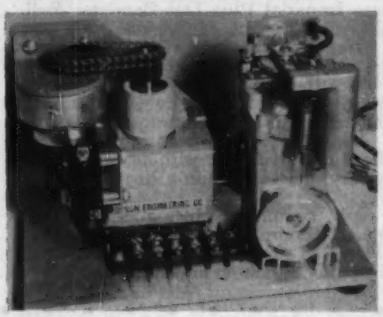
The extra heavy, cast semi-steel crankcase features thru-bolt construction with spacer blocks for maximum rigidity. The large diameter, one piece forged steel crankshaft rides in precision bearings which provide maximum effective bearing area and prevent shaft distortion.

The die forged steel connecting rods are of extra length to minimize thrust loading on crossheads while the massive crossheads feature extra large bearing surfaces. A high-capacity, direct-driven, gear-type oil pump provides full force feed lubrication. Large covers and wide spacing between compressor cylinders make all moving parts readily accessible. Clark Bros Co.

Circle E19 green card, last page

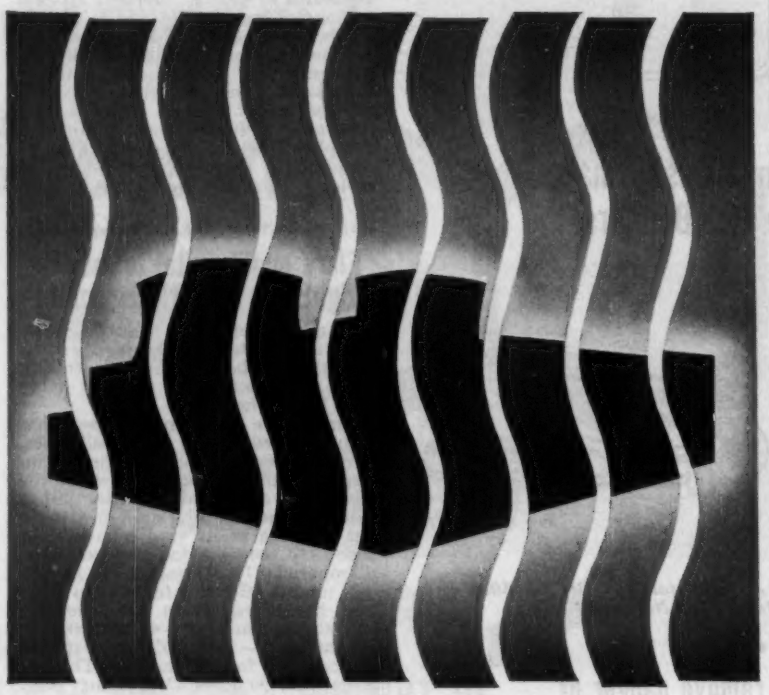
Integrator Converts Pneumatic Process Signal

A new integrator which quickly and continuously converts the input of air pressure from pneumatic process control equipment into a proportionate electrical



output of contact closures, in either a linear or square root relationship, has recently been developed. The output (up to 500 counts per minute) can then be indicated or recorded with any type of device that counts contact closures. The contacts are heavy duty and can simultaneously handle indicating and printing counters as well as pipping pens; a second contact closes once for every ten counts providing the long "tens" pip when using the dual action pipping pen. The unit, which operates on a 115-volt 60-cycle line, combines the continuous ball and disc Integrator with the Taylor Pneumatic Servo Unit and the Integrator disc is continuously driven by a synchronous motor. The measured variable, in the form of air pressure, causes the servo unit to rapidly and accurately position the ball carriage. The Integrator is available mounted in a steel cabinet hav-

Put Darlington insulation on . . .



. . . wherever waste heat comes off

In atomic power stations and oil refineries, in ships and schools and sealing wax plants, Darlington Insulation is cutting heat losses, reducing fuel consumption and saving money for industrial and commercial firms of all kinds.

With Darlington Insulation you can reduce your heat losses by up to 90%—and that means big savings on your fuel bill. Whatever your heat waste problem, there is a Darlington insulating material that can solve it. Why not ask our Technical Division for advice and assistance ? Simply write to :

THE CHEMICAL & INSULATING CO. LTD.

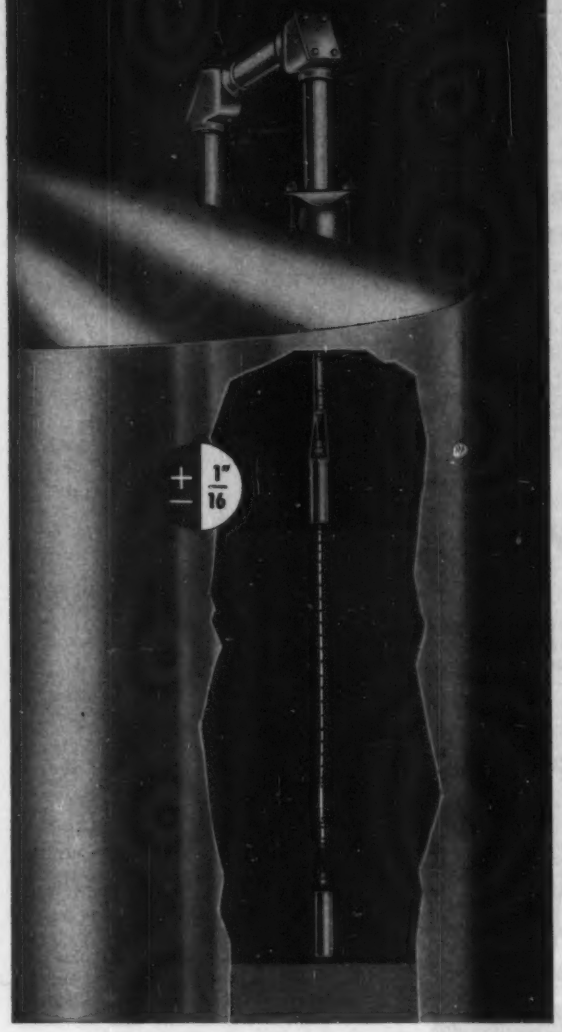
Darlington, Co. Durham

or telephone Darlington 3547

THE CHEMICAL & INSULATING CO. LTD. IS A MEMBER OF THE DARLINGTON GROUP OF COMPANIES

MH7

NOW COMPLETE AUTOMATION IN TANK GAUGING!



You can eliminate hand gauging completely with the new Gilbarco electronic Tank Gauge because this gauge measures *both product level and water interface.* At the turn of a switch the sensing element, which tracks product level, will penetrate the product to also measure water bottom. Readings of both levels can be made at the tank base or remotely on a Gilbarco Null-Balance Receiver. Gauges already installed can be equipped for this dual operation quickly, easily, inexpensively. Write for full information on the *only* gauge which gives you complete gauging automation.

Gilbarco

Gilbert & Barker Manufacturing Co.
West Springfield, Mass.
Toronto, Canada

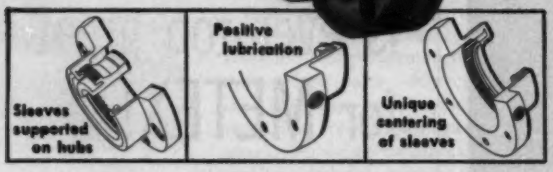
No liquid carry-over problem is ever too great for METEX!

In installation after installation...in all types of processing equipment—Metex mist eliminators are knocking back liquid entrainment...upping production...improving quality...cutting operating and maintenance costs. ■ Your particular entrainment problem is no exception. For at Metal Textile we've been knitting low-cost answers to such problems since 1943. As the originators of knitted wire entrainment separators, Metal Textile has the engineering experience—and the research and production resources necessary to support that experience—to take on even the most difficult liquid entrainment problems. Our engineering department stands ready to help you solve your particular problems with complete design assistance. For latest design guides, write or call for Bulletin ME-9: Metal Textile Corporation, Roselle, N. J.

METAL TEXTILE CORPORATION
...world's largest and oldest producer of knitted wire products
A DIVISION OF GENERAL CABLE CORPORATION

For more data on advertised products, use Readers' Service Cards, last page.

FAST'S Model B Coupling



reduces downtime and upkeep for light-to-medium drives!

Now you can profit from the durability and economy of famous Fast's couplings in a smaller and lower-cost version—available in 5 sizes for shafts ½" to 3⅛" in diameter.

The Model B coupling gives you the same features that have made Fast's the world's leading coupling for over 35 years. You get the same trouble-free performance, longer service life and lower maintenance costs. You also get prompt delivery because stocks are on hand to meet practically every need. Free engineering service is also available.

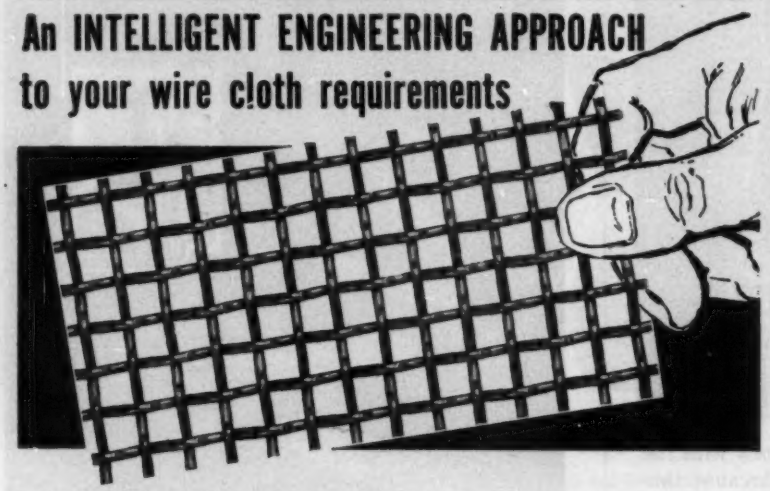
Write today for more details to KOPPERS COMPANY, INC., Fast's Coupling Dept., 6110 Scott Street, Baltimore 3, Maryland.

Engineered Products Sold with *Service*

KOPPERS

THE ORIGINAL *FAST'S Couplings*

An INTELLIGENT ENGINEERING APPROACH to your wire cloth requirements



An intelligent engineering approach to wire cloth and screen requirements pays dividends. Cleveland Wire Cloth, knowing alloy, tolerances, openings, crimping and tightness of weave, study the materials being processed, processing conditions and the end results before specifying any wire cloth. They may select from hundreds of unsurpassed quality cloth in stock, or if necessary, will weave a screen for your needs. Contact Cleveland today for an intelligent engineering approach to your wire cloth and fabricated screen problems. Ask for Bulletin No. 10.

SEE OUR AD IN REFINERY CATALOG

THE CLEVELAND WIRE CLOTH & MFG. CO.
3571 EAST 78th STREET, CLEVELAND 6, OHIO • DI 1-1832

Equipment . . .

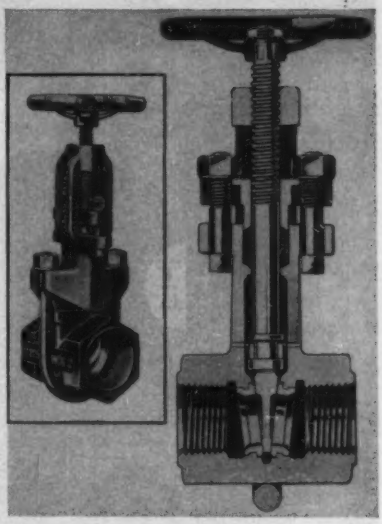
ing knockouts for electrical and pneumatic connections.

All parts of the unit are readily accessible, and when necessary, a change from the linear cam to a square root cam can be accomplished quickly and easily. Royson Engineering Co.

Circle E20 green card, last page

Gate Valves Are Designed For Corrosive Service

An improved line of "Causul" metal gate valves, designed especially for corrosive service, has been announced. The new valves, designated as Fig. 1910, are available in sizes ½ to 8 inches, with screwed or flanged ends, "King-Clip" or



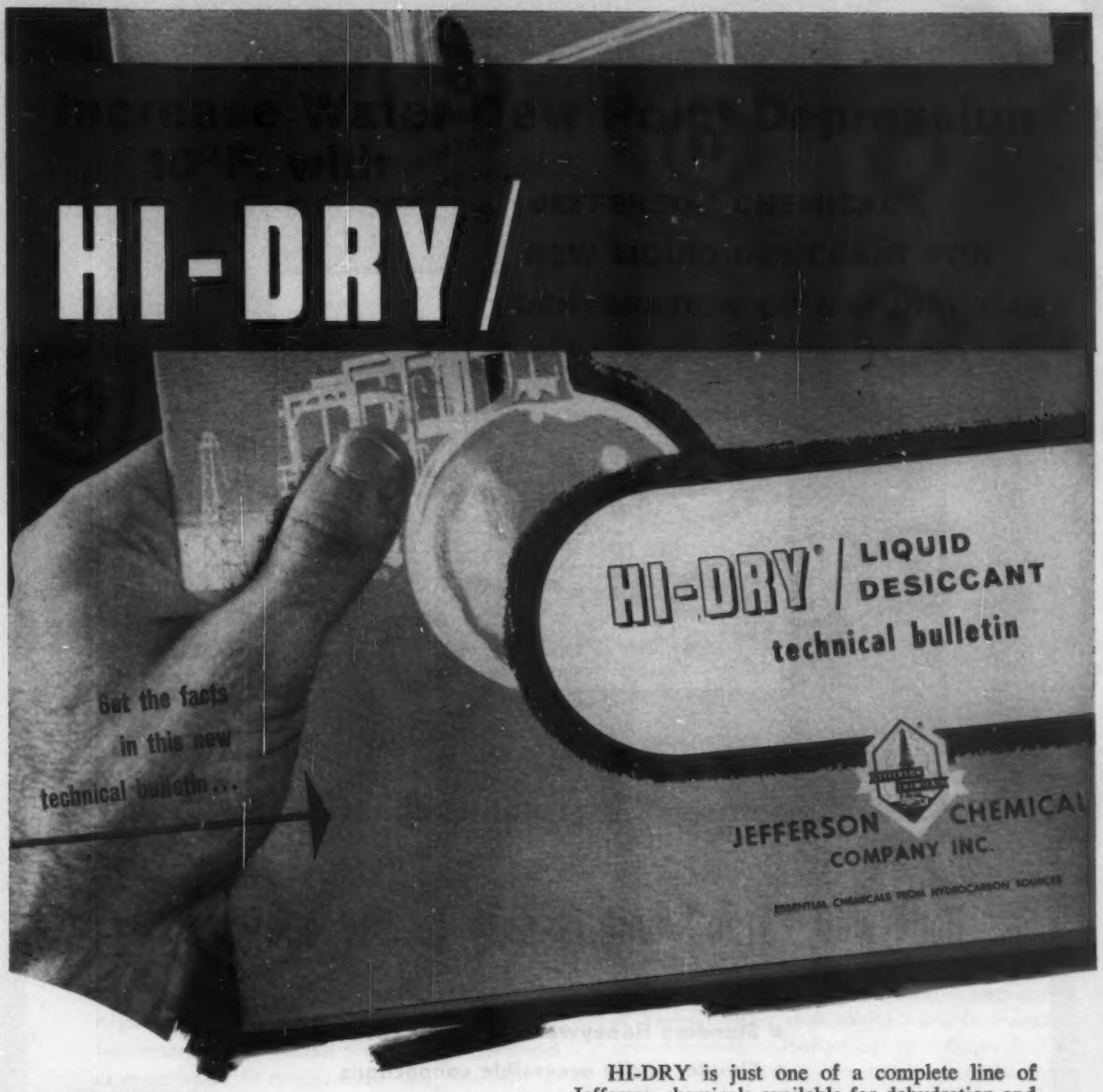
bolted bonnet type, with either stainless steel or monel trim, and are rated from 175 to 225 pounds W.O.G.

The Principal change in the new valves is the fullway design with full seat openings that maintain pressure and flow at the maximum for any specific size, ½ to 8 inches.

The material from which valve bodies, bonnets, and glands are made, is an austenitic iron, containing about 20 percent nickel, and substantial percentages of copper, chromium and molybdenum. These valves successfully and economi-

CAPACITY

SACHSE ELECTRIC INC.
BATON ROUGE LA.



HI-DRY® brand liquid desiccant is a tetraethylene glycol concentrate developed specifically to give you the extra dew point depression so often needed in the dehydration of natural gas. Extensive field tests indicate that reconcentration of HI-DRY at 435°F. and triethylene glycol at 375°F. are comparable in level of thermal stability. The lower vapor pressure of HI-DRY, in addition to the increased degree of reconcentration achievable due to its greater thermal stability, offers an advantage in the dehydration of higher temperature gas streams such as those experienced at compressor stations.

Provided in this new HI-DRY technical bulletin are sales specifications, shipping information, typical applications and physical properties. From the physical properties you may readily estimate the results obtainable with various operating conditions.

HI-DRY is just one of a complete line of Jefferson chemicals available for dehydration and sweetening. Jefferson's extensive background of experience in gas treating processes is at your disposal. For helpful technical services, samples of HI-DRY liquid desiccant, or the new HI-DRY technical bulletin . . . contact Jefferson Chemical Company, Inc., 1121 Walker Avenue, P. O. Box 303, Houston 1, Texas.

JEFFERSON CHEMICAL COMPANY, INC.

HOUSTON • NEW YORK • CHICAGO • CLEVELAND
CHARLOTTE • LOS ANGELES

Ethylene and Propylene Oxides, Glycols, Dichlorides • Ethanolamines
Morpholine • Piperazine • Polyethylene Glycols • Nonyl Phenol
SURFONIC® Surface-Active Agents • Ethylene and Propylene Carbonates
Caustic Potash • Caustic Soda • Soda Ash • Sodium Bicarbonate

Essential Chemicals From Hydrocarbon Sources

For more data on advertised products, use Readers' Service Cards, last page.

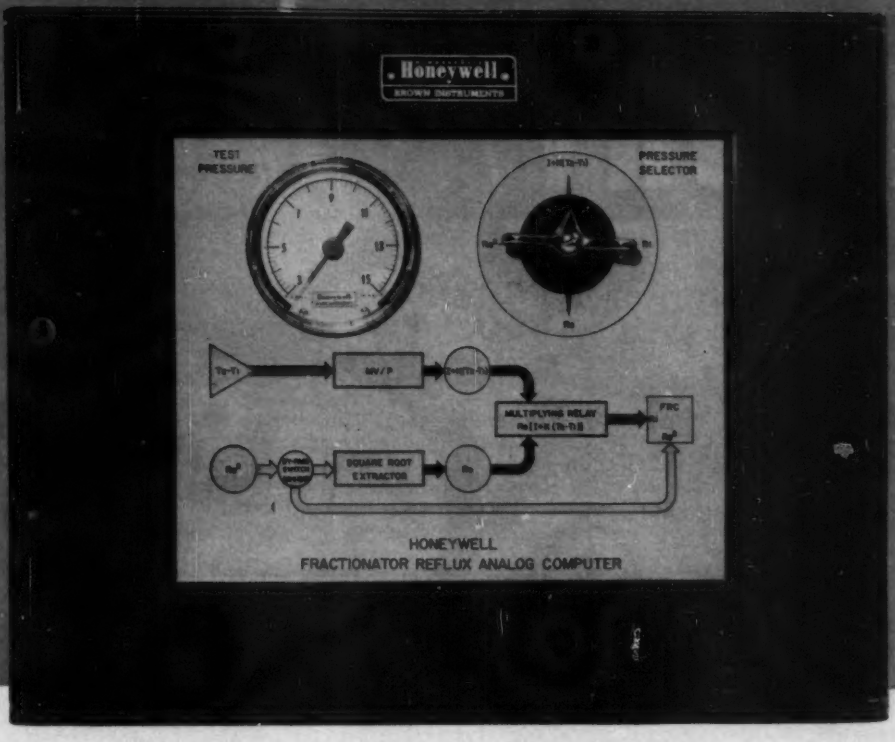
$Ri = Re\ (1 + K\ (T_2 - T_1))$

Ri—Internal reflux

Re—External reflux

$K = \frac{\text{Specific heat of Re}}{\text{Heat of Vaporization of Liquid on top tray}}$

$T_2 - T_1$—Temperature difference between external reflux steam and overhead vapor



Honeywell "Frac" unit is easy to use and maintain

- **Standard Honeywell components**
- **Standard Honeywell strip chart case**
- **Simple, easily accessible connections**
- **Chassis pulls out for front-of-case servicing**

COMPONENTS

MV/P Transmitter (millivolt-to-pressure)

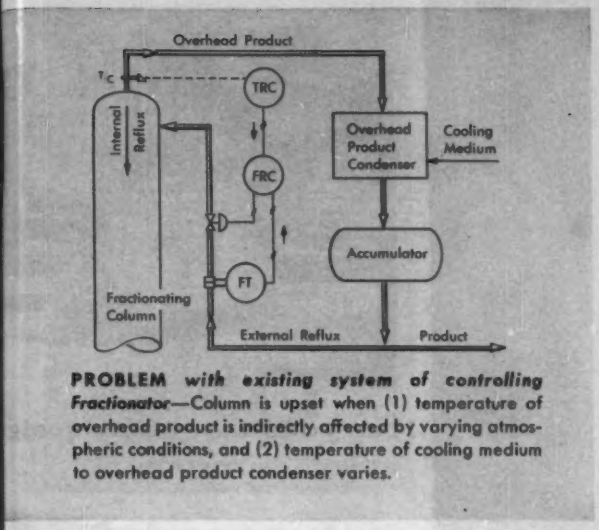
- Fully transistorized
- Continuously sensitive to temperature change
- Constant voltage supply
- Simple span and zero adjustments

Pressure selector and test pressure gage

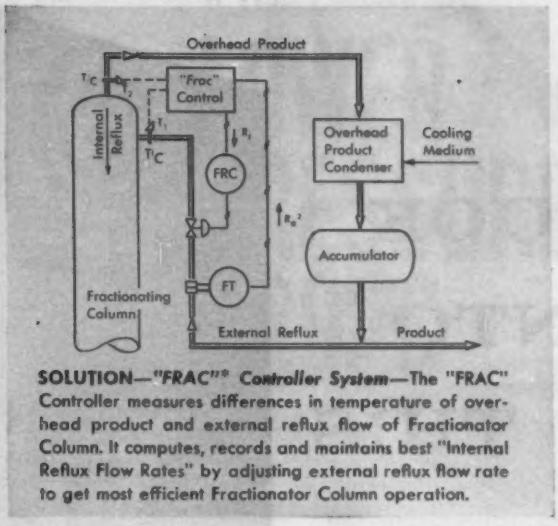
- Provide check of all pneumatic pressures within the computer for simplified trouble shooting.

By-pass switch

- Permits switching from internal to external reflux flow measurement and control.



PROBLEM *with existing system of controlling Fractionator*—Column is upset when (1) temperature of overhead product is indirectly affected by varying atmospheric conditions, and (2) temperature of cooling medium to overhead product condenser varies.



SOLUTION—*"FRAC"* Controller System*—The "FRAC" Controller measures differences in temperature of overhead product and external reflux flow of Fractionator Column. It computes, records and maintains best "Internal Reflux Flow Rates" by adjusting external reflux flow rate to get most efficient Fractionator Column operation.

New Honeywell "FRAC"* Controller stabilizes fractionating column operation

- **Easily Installed and Maintained by Present Instrument Technicians**
- **Savings Realized Justifies Installation**
- **Tamper-proof Design**

This new Honeywell control system immediately adjusts column operation to the effects of ambient temperature on overhead product condenser and external reflux. It continuously computes *internal* reflux flow, to maintain the most efficient, economical fractionating tower operation.

The new method, originally developed and licensed by Phillips Petroleum Company, utilizes a simple Honeywell analog computer employing standard industrial electric and pneumatic instrument components.

In correcting instantly for temperature deviation, the new control system offers many economies.

Less reboiler heat is required, because large surges of internal reflux that would lower temperature are eliminated. Reduction in off-specification product minimizes re-runs and the need for intermediate storage. Quicker on-stream time allows fuller use of equipment. Closer control permits fractionator to operate closer to the flooding point. Elimination of condenser temperature controls reduces both equipment costs and maintenance.

Get complete details from your nearby Honeywell field engineer. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

*Fractionator Reflux Analog Computer. Trademark, Minneapolis-Honeywell Reg. Co.

Honeywell

H HONEYWELL *First in Control*

LOOK INTO THIS

for your new-plant desig
and construction

purchasing and construction. Every type o
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cally handle sulphuric acid over a rather wide range of concentrations, alkalis, and many other corrosive fluids.

Outside stem and yoke construction is used in both designs. This places the stem threads out of the solution, which the valve must carry.

Discs in all sizes are solid Monel or 18-8 Mo. (Type 316) stainless steel, depending on type of trim.

Seat rings in the "King-Clip" design are expanded-in. Valves four inches in size and over in the 125-pound standard gate valve design, have screwed-in seat rings, which are renewable. They are of the bottom seating type. All seats are full opening. Lunkenheimer Co.

Circle E21 green card, last page

Orifice Plate Catalog Gives Design Information

A new Catalog Section "G" on orifice plates, sealing units, and ring-type joint plate holders is now available.

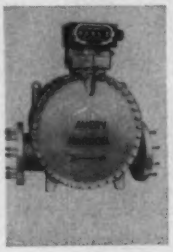
Universal size orifice plates for use in orifice fittings are included, as well as paddle type orifice flange plates, and plates for flow sections. The bulletin describes three sealing units, the "Dual," "Teflon," and Metallic Seals.

Complete information on design, sizes, A.S.A. pressure ratings, and materials is given in the eight-page bulletin. Daniel Orifice Fitting Co.

Circle E22 green card, last page

High Flow Rate Meter Designed For Bunker Fuels

Hitherto, the largest size bulkmeter in the company's range has been the BM. 600 with a rated capacity of 650 Imperial gallons per minute, (2955 lpm).



The range has now been extended by introducing a bulkmeter with greatly increased capacity. Designated the LBM 1,000, the new bulkmeter has been designed for high flow rates, including bunkering with heavy fuels, and is equally suitable for light petroleum products, having a rated capacity of 1,500 Imperial gallons per minute (6,800 lpm) on fuel oil with a viscosity of 2,500 Redwood seconds 1 at 100° F.

The production model of the new meter will be fitted with a Veeder-Root reversing counter and has inlet and outlet in-line flanges of 8 inch internal diameter. The approximate overall dimensions are 36 inches in height, 40 inches in width and 20 inches in depth. The LBM. 1,000 is suitable for normal operating pressures up to 300 psi and is tested to 500 psi to withstand any surge pressures which may be experienced. Avery-Hardoll Ltd.

Circle E23 green card, last page

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with ARLCITE CATALYST BED SUPPORTS

Super-strong ARLCITE Spheres insure minimum pressure drops in product flow through catalyst bed supports. Of special high-density alumina-ceramic composition, Arlcite Spheres have high compressive strength combined with extreme resistance to thermal shock.

Repeated temperature cycling, years of service will not cause Arlcite to crumble, split or chip. The interstices between the balls thus remain free of fines to maintain a constant low pressure drop. Investigate the economy of ARLCITE Spheres in *your* catalytic refining process. Write!

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Advertisers in This Issue

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*The asterisk preceding name of advertiser indicates that detailed data on products and services of the firm will be found in The 1959 Refinery Catalog.

A

*ADSCO Division
Yuba Consolidated Industries, Inc. 68
*The Air Preheater Corp. 4
*Airetool Manufacturing Co. 294
Allied Chemical Corp.
General Chemical Division 352
Allied Chemical Corp.
Solvay Process Division 12
Alloy Steel Products Co. 51
The Allpax Co. 305
*Aluminum Company of America 187
*American Air Liquide 308
American Bitumuls & Asphalt Co. 284
*The American Brass Co. 8
American Cyanamid Co.
Refinery Chemicals Dept. 327
American Steel & Wire Division
United States Steel 188-189
Amoco Chemicals Corp. 228
*The V. D. Anderson Co. 267
Austin-Western Construction Equipment
Division, Baldwin-Lima-Hamilton Corp. 250
Avondale Marine Ways, Inc. 256

B

The Babcock & Wilcox Co. 32, 73
The Babcock & Wilcox Co.
Tubular Products Division 270
*Badger Manufacturing Co. 78
Baldwin-Lima-Hamilton Corp. 250, 260, 322b
Barber-Colman Co. 66
*Barco Manufacturing Co. 252
*Barrett Manufacturing Co. 316b
Beckman Instruments, Inc. 45
Betz Laboratories, Inc. 64-65
Bingham Pump Co. 49
Birlec Limited 34-Lb
*Black, Sivalls & Bryson, Inc. 301
*Blaw-Knox Co. 40, 321
Branson Instruments, Inc. 262
The Bristol Co. 266
*British Ermeto Corp. Ltd. 34-J
Brown & Root, Inc. 80
*The Brown Fintube Co. 180-181
*Buell Engineering Co. 11
*Buffalo-Eclipse Corp. 318
Burrell Corp. 254

C

*Calumet & Hecla, Inc. 209-210
*Camco Fittings, Inc. 271
*The Cape Asbestos Co. Ltd. 41
Carter-Waters Corp. 328c
*Catawissa Valve & Fittings Co. 240a
Cathodic Corrosion Control Ltd. 34-Ma
*Causeway Reinforcement Ltd. 334
Celanese Corporation of America 34
The Chemical & Insulating Co. Ltd. 336
*Chemical Construction Corp. 33
*Chiksan Co. 285
*Clark Bros. Co.
One of the Dresser Industries 25
Classified Advertising 313
*The Cleveland Wire Cloth & Mfg. Co. 338a
*Coffin Turbo Pump Co.
Division Food Machinery & Chemical Corp. 309
The Colorado Fuel & Iron Corp. 50
Columbia-Geneva Steel Division
United States Steel 36, 188-189, 295
Consolidated Electrodynamics Corp. 297
*The Cooper-Bessemer Corp. 22-23
Crane Co. 179
Crane Packing Co. 330
Crouse-Hinds Co. 6
*Curtiss-Wright Corp.
Metal Processing Division 300
Curtis-Wright Corp.
Princeton Division 256

D

Darling Valve & Mfg. Co. 81
De Laval Steam Turbine Co. 61
Dover Corp. 26
Dowell 247
*Dresser Industries, Inc. 25
E. I. du Pont de Nemours & Co. 14
Durabla Manufacturing Co. 268
The Duraloy Co. 281

E

*E. C. D. Limited 34c
The Eagle-Picher Co. 248
Eddystone Division
Baldwin-Lima-Hamilton Corp. 260
*Elliott Co. 96, 191
Engelhard Industries, Inc. 233
Ethyl Corp. 16-17, 20
Evershed & Vignoles Ltd. 34-F

F

Farris Engineering Corp. 274
Ferro Corp. 343
*Fisher & Ludlow Ltd. 34-G
Fisher Governor Co. 89, 257
*Fluor Products Co.
Division The Fluor Corp. 241
*Food Machinery & Chemical Corp. 309
The Foram Corp. 331b
Forge & Fittings Division
H. K. Porter Company, Inc. 276
Benjamin Foster Co. 54
*Foster Wheeler Corp. 29
The Foxboro Co. 59

G

The Gamewell Co. 86, 263
*The Garlock Packing Co. 279
General Cable Corp. 337b
General Chemical Division
Allied Chemical Corp. 352
Gilbert & Barker Mfg. Co. 337a
*Goulds Pumps, Inc. 55
*Graham Manufacturing Co. 265
Gray Tool Co. 310a
A. P. Green Fire Brick Co. 97
Grill Floors Ltd. 34-Kb
*Grinnell Co. 306-307
Gutehoffnungshuette 331b

H

H & E Lintott Ltd. 34-B
Harrisburg Steel Co.
Division Harsco Corp. 249
Harsco Corp. 249
*The Harshaw Chemical Co. 62
*Hartzell Propeller Fan Co. 261
*Heliflow Corp. 265
*Hendrick Manufacturing Co. 259
Hercules Powder Co. 310b
*Hudson Engineering Corp. 243
Humble Oil & Refining Co. 77
Hydromatics, Inc. 20

I

The Imperial Brass Mfg. Co. 335
Industrial Products
Parkinson Cowan 34-La
Infilco, Inc. 253
*Ingersoll-Rand Co. 94, 177
The International Nickel Co. 185, 231
International Process Equipment Co. 194
*Irving Subway Grating Co. 316c

J

Japan Gasoline Company Ltd. 63
Jefferson Chemical Co. 339
Jessop Steel Co. 197
*Johns-Manville Corp. 21, 183, 324-325

K

Kano Laboratories 240b
*Keasbey & Mattison Co. 290-291
The M. W. Kellogg Co. 299
Kerotest Manufacturing Co. 206
S. P. Kinney Engineers, Inc. 269a
*Richard Klinger Ltd. 34-E
*Koch Engineering Co. 202
Koppers Co. 213, 309, 343a
Koven Fabricators, Inc. 302a

L

*Lake and Elliot, Ltd. 34-Mb
Langley Alloys Ltd. 34-A
*Larkin Packer Co. 67
*The Lummus Co. 193

M

*The Mack Iron Works Co. 331a
Madsen Works
Construction Equipment Div.
Baldwin-Lima-Hamilton Corp. 322b
Manning, Maxwell & Moore, Inc. 48, 205, 304
Olin Mathieson Chemical Corp. 196
*McGraw-Edison Co. 320
Arthur G. McKee & Co. 342
Metal Textile Corp.
Division General Cable Corp. 337b
Minneapolis-Honeywell 83, 222-223, 287, 340-341
*Mixing Equipment Co. 221
Mueller Co. 95

N

Nalco Chemical Co. 56-57
*National Airoil Burner Co. 298
National Lead Co. 277-278
National Tube Division
United States Steel 36, 188-189
*National-U. S. Radiator Corp. 289
Nelson Electric Mfg. Co. 292
*New England Tank & Tower Co. 43
Newalls Insulation Co. Ltd. 35
Newport News Shipbuilding & Dry Dock Co. 58
*W. C. Norris, Manufacturer
Division Dover Corp. 26
*Norton Co. 314

O

*Oakite Products, Inc. 85
Orbit Valve Co. 31

P

Panellit, Inc. 328b
Parker Seal Co.
Division Parker-Hannifin Corp. 217
Parkinson Cowan
Industrial Products 34-La
The Patterson Foundry & Machine Co.
Subsidiary Ferro Corp. 343
*Penberthy Manufacturing Co.
Division Buffalo-Eclipse Corp. 318
*Petroleum Refiner 244
*Pfaudler Permutit Inc. 332-333
*Phelps Dodge Copper Products Corp. 18-19
The Pipe Fabrication Institute 317
*Pittsburgh Lectrodryer Division
McGraw-Edison Co. 320
H. K. Porter Company, Inc. 91, 276
The Wm. Powell Co. 76
The Pyrene Co. Ltd. 34-D

R

*R-P & C Division
American Chain & Cable Co. 326
*The Refinery Catalog 46-47
Research-Cottrell, Inc. 218
The Ridge Tool Co. 269-C
*Rockwell Manufacturing Co. 272-273
*Rockwood Sprinkler Co.
Division The Gamewell Co. 86, 263
Royal McBee Corp. 28

S

Sachse Electric Inc. 338b
*Sarco Co. 84
Scoville Manufacturing Co. 81
*Schutte & Koerting Co. 198
*Selas Corporation of America 27, 275
Shand & Jurs Co. 323
The Sharples Corp. 24
Shell Oil Co. 52
*M. B. Skinner Co. 316a
C. K. Smoley & Sons, Inc. 302b
Snap-Tite, Inc. 201
Socony Mobil Oil Co. 282-283
Solvay Process Division
Allied Chemical Corp. 12
Standard Brass & Manufacturing Co. 71
Standard Oil Company (New Jersey) 251
Stauffer Chemical Co. 93
Stockham Valves & Fittings 293
*Strong, Carlisle & Hammond 74
*Sun Shipbuilding & Dry Dock Co. 37
The Swartwout Co. 88

T

*Taylor Instrument Companies 214
Tennessee Coal & Iron Division
United States Steel 188-189, 295
*The Terry Steam Turbine Co. 72
Thermoid Division
H. K. Porter Company, Inc. 91
Toledo Pipe Threading Machine Co. 245
The Trane Co. 30
*Tretolite Co.
Division Petrolite Corp. 44
Tubular Products Division
The Babcock & Wilcox Co. 270
27th Exposition of Chemical Industries 92

U

Union Carbide International Co.
Division Union Carbide Corp. 34-H
U. S. Electric Motors, Inc. 75
United States Rubber Co. 42
United States Steel Corp. 36, 188-189, 295
United States Steel Export Co. 36, 188-189, 295
United States Steel Supply Division
United States Steel 36, 188-189, 295
*The U. S. Stoneware Co. 87
Universal Oil Products Co. 38-39, 90, 288

V-Z

The Vapor Recovery Systems Co. 319
Henry Vogt Machine Co. 53
*Vokes Genspring Ltd. 34-Ka
*J. H. H. Voss Co. 328a

Wallace Supplies Mfg. Co. 242
Walworth Co. 60
Warren Petroleum Corp. 224
Wells Manufacturing Corp. 296
Western Supply Co. 195
Westinghouse Electric Corp. 82
*The Gustav Wiedeke Co. 322a
T. D. Williamson, Inc. 329
*Thomas C. Wilson, Inc. 255
*Wolverine Tube Division
Calumet & Hecla, Inc. 209-210
*Worthington Corp. 69-70, 311-312
Wright-Austin Co. 269b
Wyatt Metal & Boiler Works 351

*Yarnall-Waring Co. 2
*Yuba Consolidated Industries, Inc. 68

*Zallea Brothers 280

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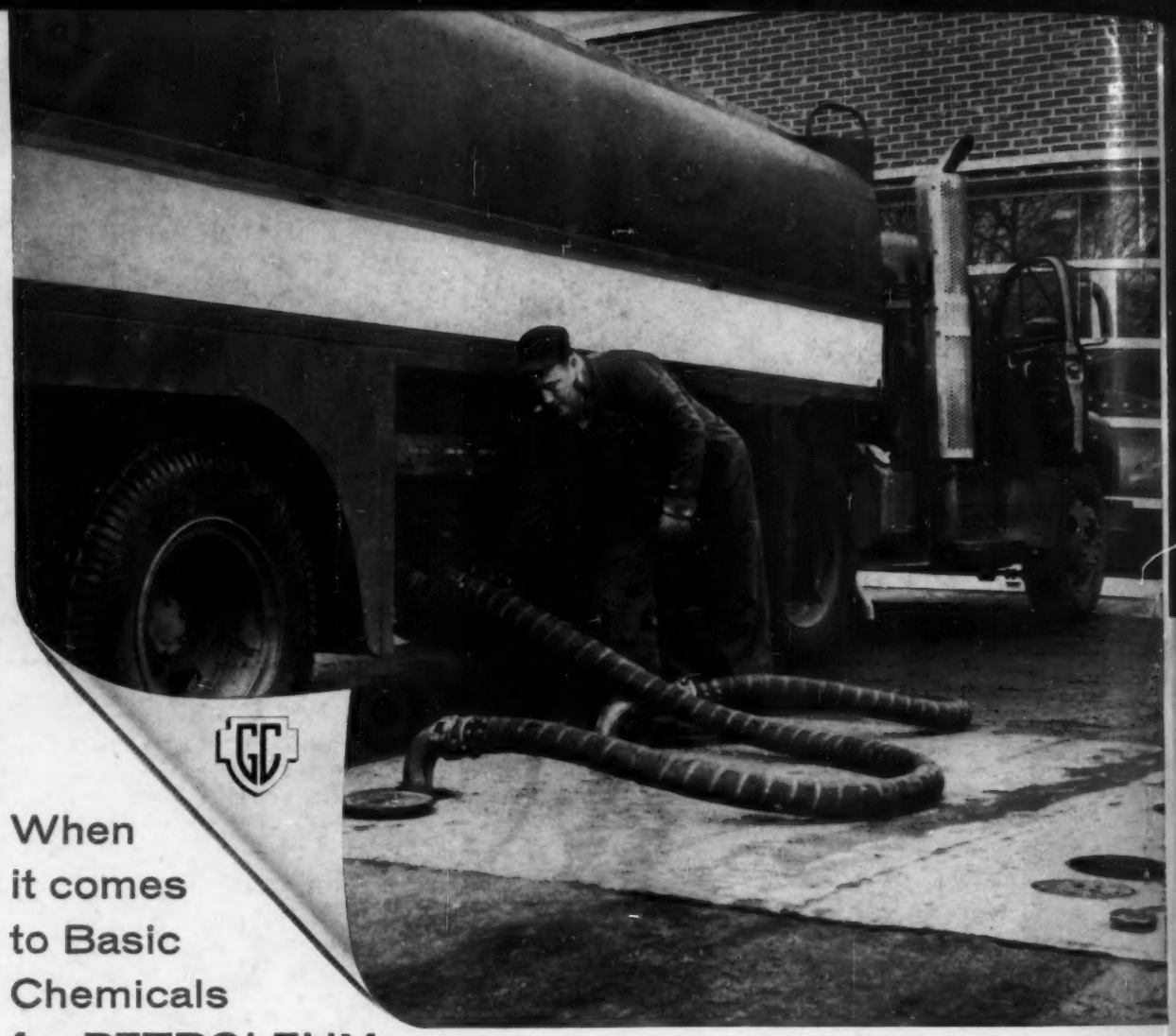

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